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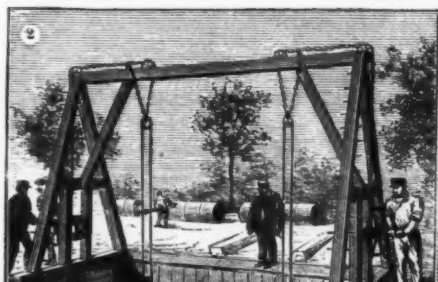
LEADING OF THE WATER OF THE AVRE TO PARIS.

THE principal main of the water of the Avre, beginning at the Montretout reservoir, consists of riveted steel pipes, 5 feet in diameter and a half inch in thickness. Each pipe is 19½ feet in length, and weighs about 6,600 pounds. By reason of their weight and size, the laying of these pipes presented some difficulty. As the arched gallery had been established by the masonry contractors, it would have been necessary, had the ordinary methods of carriage by trucks been employed, to first put in place the supports designed to carry the pipes, and then raise each of them again on the spot in order to lay them and make the joints. Moreover, the use of trucks moved by manual power in a long gallery could not be thought of, and mechanical traction was necessary.

Engineer Gibault, who had the contract for laying the conduits, solved these problems in a very elegant and practical manner by the aid of three apparatus, comprising a car for carrying the pipes, a centering apparatus to permit of making the joints easily, and a small electric locomotive.

FIG. 1.—LAYING THE LARGE PIPES FOR CARRYING THE WATER OF THE AVRE TO PARIS.



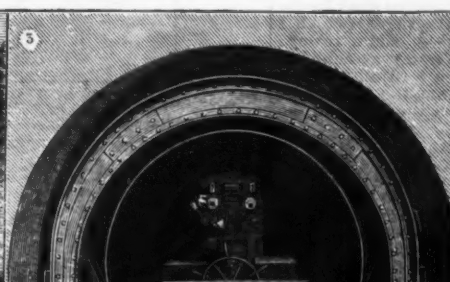


FIG. 2.—WINDLASS FOR LOWERING THE PIPES. FIG. 3.—SECTION OF THE CAR.

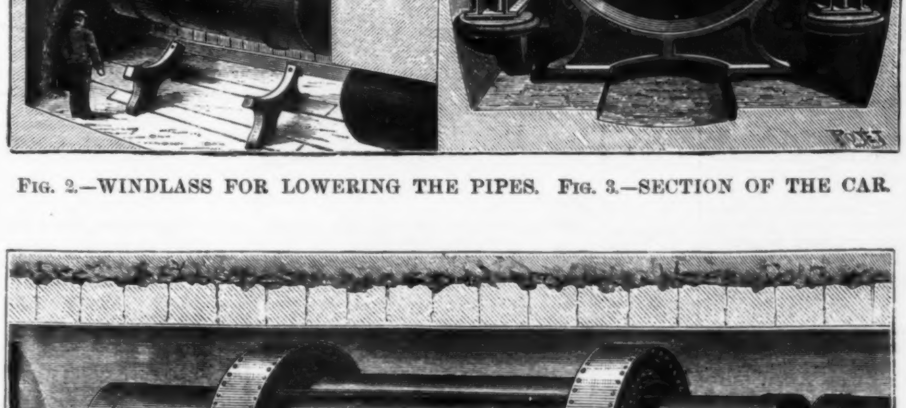


FIG. 4.—CAR FOR CARRYING THE PIPES.

The car, shown in Figs. 3 and 4, consists of a curved frame carried by a four-wheeled truck, which runs upon the floor of the gallery, and is held at a distance from the walls by four horizontal rollers with rubber-covered rims. At the extremities of the truck frame are placed four hydraulic jacks, whose heads carry fork links terminating in flat bars which engage with the lugs of the pipe support and permit of lifting each pipe and its two supports at the same time.

These various pieces are placed upon the car as follows (Fig. 2): The roof of the gallery is opened for a length of about 23 feet, and above the excavation thus formed is arranged a windlass with two slings. The pipes and supports, placed in a line along the road under which the gallery passes (Fig. 1), are carried to the right of the excavation by a small lateral track. The supports are first let down upon a template upon which the car is afterward drawn. The pipe is then lowered, and when it rests upon the supports, the bars of the fork links are passed into the lugs of the supports, and the whole is lifted by means of the jacks. In order to prevent any strain upon the latter during the carriage of the load, they are eased by means of wedges. The locomotive then hauls the car and the complete section to the last pipe laid. The pipe and supports are deposited upon the floor by means of the jacks, and the locomotive hauls the car back to the loading point. During the intervals between the returns, loaded and empty, the workmen form the joint.

This latter is formed, as shown in Fig. 5, of a ring, A, cylindrical externally and conical internally. It is held tight between two other rings, B and C, the profile of which presents a channel in which is placed a rubber washer, D. The external rings, B and C, are secured by 30 bolts, six-tenths of an inch in diameter. It will be seen from the figure that the tightening has the effect of pressing the rubber into that part of the channel not occupied by the ring, A, so as to form a self-closing joint.

The centering apparatus consists of a carriage guided laterally by two pairs of pulleys, having rubber rims and resting in the vertical plane upon two wheels, m m' (Fig. 6). The hub of one of the wheels, m, carries a ratchet wheel and a lever which serves for the advance or return. Upon the truck there is established a fixed screw, v, the nut of which carries rods, q, jointed on the one hand to the body of the nut, and on the other to other rods, r. The latter are also jointed to a stationary disk, p. The whole forms a sort of umbrella frame that is opened or closed by means of the hand wheels, g and g'. The last pipe laid carries one of the external rings, the rubber washer and ring, A. The following pipe arrives with the other external ring and its rubber washer. The centering is effected by opening the "umbrella" so as to make the rods, r, bear against the internal surface of the cylinder; then the bolts are tightened throughout the entire circumference. The car is afterward pulled back in order to form the following joint. The maneuver is performed very easily.

The locomotive, like the car, carries lateral guides. The motive power and the light are furnished by a battery of forty accumulators, placed in a box back of the truck. The front is occupied by a small 3 h. p. dynamo and by the transmission of motion. This latter is effected by fast and loose pulleys in such a way as to obtain a change of direction easily and without shock. The accumulators are charged at night by means of an installation established near the opening in the roof of the gallery and that consists of a 6 h. p. movable steam engine and a 5 h. p. dynamo. The maximum voltage at the charging is two and a half volts. Under such conditions, the locomotive always disposes of its entire power.

The coupling of the locomotive and car is effected through the intermedium of a screw hand wheel. Another hand wheel, placed in front of the truck, and a brake permit, when the end of the already joined conduit is reached, to push the whole system (locomotive and car) by hand so as to engage the extremity of the new section with the centering apparatus. It is then necessary to give a slight shock, which the

brake reduces to the proper limit. These ingenious arrangements permit of laying ten sections, say 195 feet, of piping per day, with a mean travel of 650 feet for the engine.

The laying of these pipes of large diameter is thus

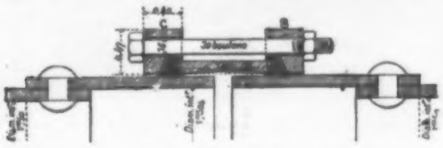


Fig. 5.—JOINT OF THE CONDUITS.

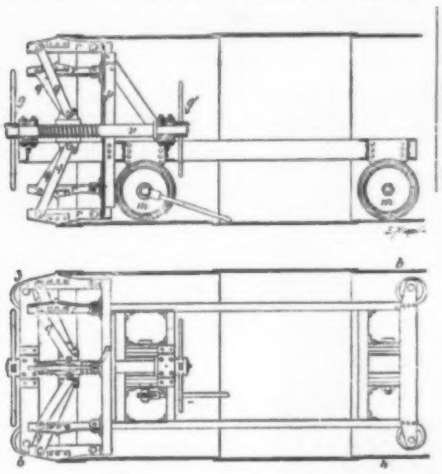


Fig. 6.—ELEVATION AND PLAN OF THE CENTERING APPARATUS.

effected in a manner that is at once precise and economical, and that does honor to the inventor.—*La Nature.*

LIFE SAVING DEVICES.*

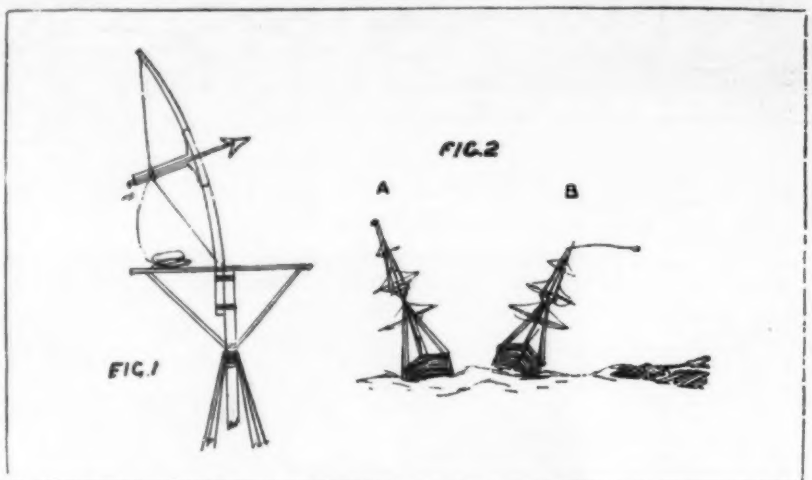
The suggestion sent by Mr. A. H. Watts is decidedly novel. He says: "I append herewith an idea for utilizing the topmast as a bow. The machine for bending the mast would be fixed by iron bands on to the mast and would swivel in any direction. An arrow could be fired from this, having a cord attached to its tail end. I also sketch an idea of a contrivance similar in action to a man throwing a ball. I utilize the mast of the vessel in place of an arm, and the impetus shall be derived from the rocking motion of the vessel (which I think I am right in saying invariably comes toward shore broadside to land). A heavy lead is attached to topmast part of the vessel, having a cord affixed. In A the vessel is at such an angle that the topmast is furthest from land. In B it is nearest the land and the lead is let go."

"A wave boat" is the design of Mr. H. F. Hornsnaill. It is a frame of wooden spars with movable spars or shutters between. The movement of the waves up and down through the shutters is to cause the boat to travel. It will, the inventor says, travel indifferently on either side. It is to be guided by the wind against that part marked D showing above the water-line. The other part marked D will act as a rudder in the water, and should the boat be upset the previously submerged D becomes the wind-guide and the other the rudder. D must be adjusted before launching to point to the wind, the boat at the same time pointing toward the shore to which it is to go. It is intended that the boat shall carry and pay out its own rope. The references are: AA, frame of wooden spars; BBB, shutters movable about 30° above and below surface line; C, coil of rope; D, rudder and wind guide, working either way up; EE, keels; FF, cork floats; GG, iron stays; HH, spike anchors attached by hinges and chains as shown.

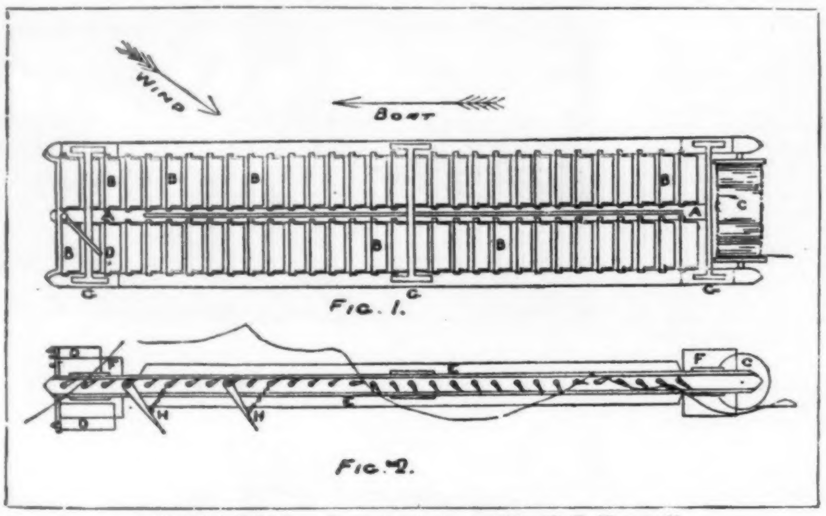
"The Dolphin" of Mr. W. Sidney Randall is to be constructed of cork and other light materials, and is intended to carry a man to the shore. The man sits on the dolphin's back at M. His legs go down into holes on each side shown by dotted lines, so that they are protected. If necessary he can steer with the rudder R. AA is the dolphin, B the grapnel attached under it, carrying line D from ship. On landing, the grapnel is pulled out from B and C, and fixed on shore. F is the dolphin's mouth holding an umbrella grapnel with line dischargeable by a coiled spring. If there is any difficulty in landing, this can be liberated by the trigger, T. E is the dolphin's eye through which a light could be shown, H a short mast to hold a sail to drive the boat ashore, and at S is a flare signal to be let off when the line is secured. At X is a vent for oil which could be provided.

From Mr. Cresswell Woollett comes an invention by which he says progression should be as easy on shore as at sea. He says his invention will allow a man to cruise about at night or day from a stranded ship with a view of finding the safest landing place for the distressed crew. He would be perfectly safe in a rough sea, as the machine could not turn over, being constructed on the raft principle. It would consist of an iron box, with a lid opening at the top. It would have a plate glass front and bull's eye lanterns inside, "so that the man could distinctly see to what part he was making." The man is to work the two paddle wheels with his hands, thus being able to steer, and when the lower wheels touch the ground, he is to commence to work the treadles, which should enable the machine to run up the beach. There would be a small hand-pump fixed to the box to pump out any water that may get in during the working of the paddles, and a life line could be fixed to the machine with a spike to fix to the shore. The inventor says: "The dimensions I have given may be reduced. I also suggest that a larger machine, worked with four paddles on the same principle, say to seat twelve persons, should be kept at each coastguard station. These could be made light enough to be run down any steep incline, the wheels being the same."

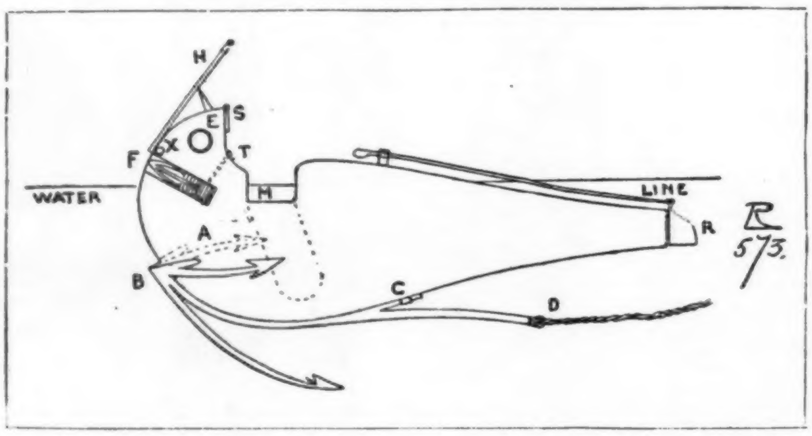
Mr Clark calls his invention, which has been patented, "a pneumatic life-saving projectile for getting communication between a stranded ship and the shore." The outside case of the projectile is made of wrought iron or steel tube, lipped in three places at



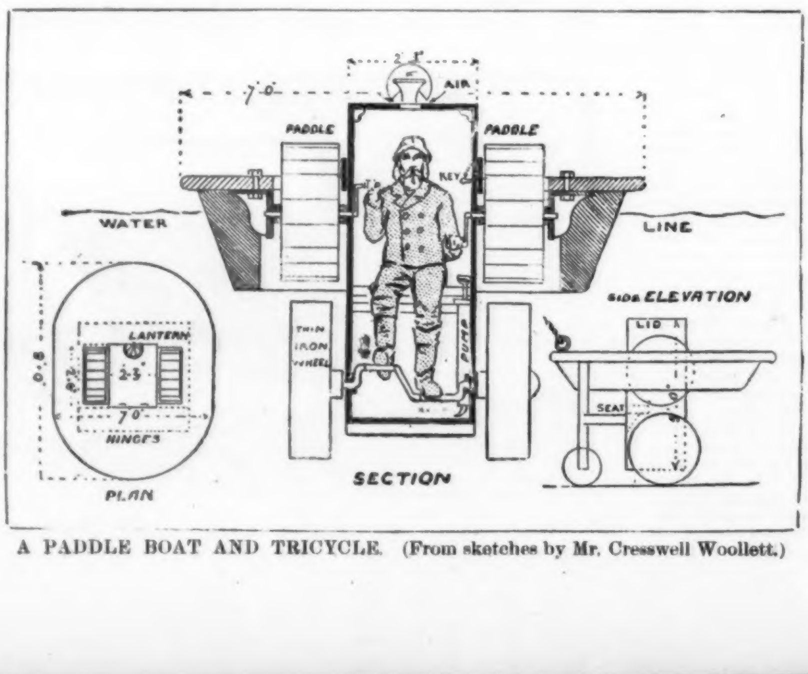
THE MASTS AS BOWS AND "LEAD SLINGS." (A suggestion by Mr. A. H. Watts.)



A WAVE BOAT. (From the designs of Mr. H. F. Hornsnaill.)



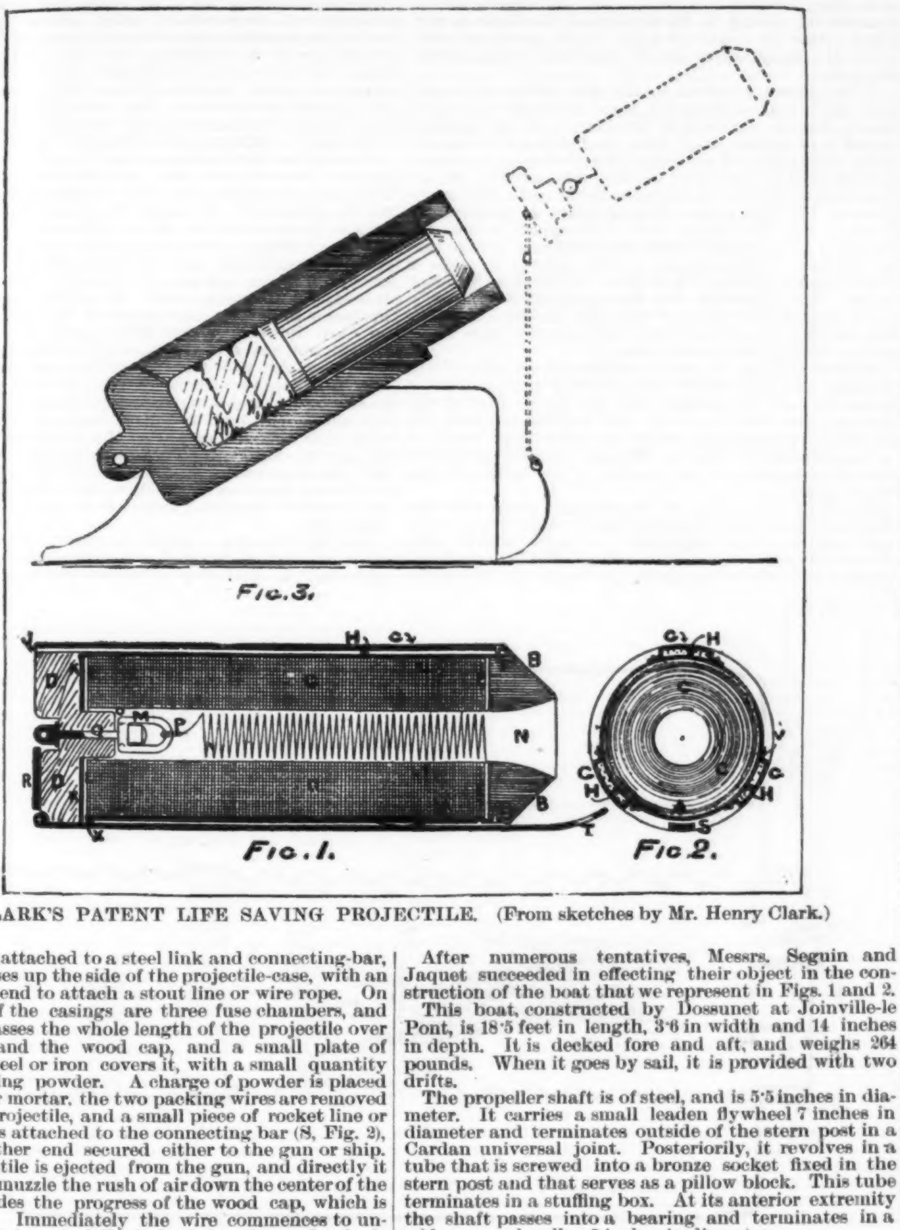
"THE DOLPHIN" LINE CARRIER. (From a sketch by Mr. W. Sidney Randall.)



A PADDLE BOAT AND TRICYCLE. (From sketches by Mr. Cresswell Woollett.)

* Continued from Supplement, No. 864, page 13804.

the back end to prevent a coil of wire from falling out. This coil is wrapped on a tapered mandrel so as to uncoil from the inside at the back or large end, toward the front or small end. The nozzle is made of cast iron or steel, and is secured to the casing by means of small screws. The coil is composed of annealed steel wire, either one or more strands. The wire is attached to the hard wood cover at the back end by means of a thimble and swivel. A small bolt passes through the cap and is attached to a steel link and connecting-bar, which passes up the side of the projectile-case, with an eye at the end to attach a stout line or wire rope. On the sides of the casings are three fuse chambers, and the fuse passes the whole length of the projectile over the edge and the wood cap, and a small plate of roughed steel or iron covers it, with a small quantity of detonating powder. A charge of powder is placed in a gun or mortar, the two packing wires are removed from the projectile, and a small piece of rocket line or wire rope is attached to the connecting bar (S, Fig. 2), and the other end secured either to the gun or ship. The projectile is ejected from the gun, and directly it leaves the muzzle the rush of air down the center of the shot impedes the progress of the wood cap, which is forced off. Immediately the wire commences to uncoil, and it is materially helped by the rush of air down the center against the coils, which are all wrapped free to be forced out of the tapered hole. This rush of air causes an alarm to whistle, and the tearing off of the wood cap ignites the fuse for the signal. Fig. 1 is a longitudinal section of the projectile, and Fig. 2 a cross section. The references are: A, of steel tube; B, cast-iron muzzle; C, annealed steel wire coil; D, hard wood cap; E, leather washer; F, set screws; G, flat fuse; H, fuse chambers; I, steel plate; J, detonating powder; K, steel washer; L, leather washer; M, small shackle to take wire; N, bell-mouth nozzle; O, enlarged end of air passage; P, thimble for wire; Q, bolt; R, link; S, steel connecting-bar; T, eye for steel wire rope; U, flannel jacket; V, rivets; X, lip of steel casing. In Fig. 3, the mortar is shown with the projectile and charge ready. The dotted lines show the projectile leaving the gun.



CLARK'S PATENT LIFE SAVING PROJECTILE. (From sketches by Mr. Henry Clark.)

SEGUIN & JAQUET'S PROPELLER LAUNCH.

PROPELLER boats, and more especially those for pleasure and sport, and consequently of small dimensions, have a certain number of inconveniences. They are heavy and are strongly ballasted at the stern in order to immerse the screw, and it follows that access to water of slight depth is denied them. Besides, the dead weight to be set in motion is considerable. They cannot be propelled by screw or oars at will; and then, again, a pleasure sailboat cannot be provided with a screw, seeing that it would be necessary when the wind blew to drive it through the water with a great resistance, unless recourse were had to the very costly construction of a screw tunnel.

It is expensive to keep them in repair, and they are rather incommodious on account of the presence of the boiler and mechanism. Finally, they are in most cases very noisy, and this for hunting boats is a great inconvenience, involving the use of large and dangerous duck guns difficult to maneuver.

Struck by these weak points, Mr. Alfred Seguin, formerly a captain in the merchant service, well versed in nautical affairs and an ardent sportsman, interested his friend Mr. Jaquet in studying with him the construction of a boat more especially designed for hunting upon water and which should realize the following desiderata:

This boat, constructed in the form of a canoe, that is to say, pointed at the stem and stern, was to be able to go by sail, oars or screw, indifferently. Despite a very feeble draught of water (4 inches), it was to be able to be moved by a screw capable of giving it a speed of 3 or 3½ miles an hour and liftable out of the water at will. It was to be able to execute its evolutions with ease; and finally, it was necessary that the engine should be capable of being dismounted and set up again with rapidity.

After numerous tentatives, Messrs. Seguin and Jaquet succeeded in effecting their object in the construction of the boat that we represent in Figs. 1 and 2.

This boat, constructed by Dossunet at Joinville-le Pont, is 18·5 feet in length, 3·6 in width and 14 inches in depth. It is decked fore and aft, and weighs 264 pounds. When it goes by sail, it is provided with two drifts.

The propeller shaft is of steel, and is 5·5 inches in diameter. It carries a small leaden flywheel 7 inches in diameter and terminates outside of the stern post in a Cardan universal joint. Posteriorily, it revolves in a tube that is screwed into a bronze socket fixed in the stern post and that serves as a pillow block. This tube terminates in a stuffing box. At its anterior extremity the shaft passes into a bearing and terminates in a wide-grooved pulley 5 inches in diameter.

A cast iron flywheel 18 inches in diameter moved by two pedals drives a belt of twisted leather which passes over two guide rollers and engages in the groove of the shaft pulley. The ratio of speed is 1 : 3·2. In normal operation, from 40 to 45 revolutions of the pedal are made per minute, say 150 revolutions of the screw. The weight of the internal mechanism inclusive of the flywheel is about 440 pounds.

The screw shaft, which is prolonged beyond the stern post by a Cardan joint, as above stated, actuates a small shaft about 30 inches in length, at the end of which is fixed a three-bladed screw 14 in. in diameter.

The screw is thus perfectly free to move sideways and upward and downward. A lever of two arms, one of which carries the rudder bar and the pivots that serve to fix the whole to the stern of the boat, and the other a collar that slides on the shaft of the screw, permits of acting upon the latter and of making a true rudder of it.

If it is desired to use oars, a small lever permits of instantaneously raising the screw, which then becomes fixed to a catch carried by the lever. If it is desired to use the screw, the small lever, and, with it, the screw, is allowed to descend and the motor is then set in operation. The steering is done by acting upon the bar, which, being connected with the small shaft of the screw, moves the latter to the right and left of the axis of the boat, and permits of evoluting with more perfect ease.

The advantages of this boat are as follows: In the first place, its speed is quite high as compared with that of hunting boats provided with a screw actuated by hand, which make but from 1¼ to 1¾ mile per hour at the most. With their boat, Messrs. Seguin and Jaquet have obtained the following speeds: with the screw, 725 feet in one minute and forty seconds, say 26,095 feet per hour; with oars, 725 feet in one minute and 34 seconds, say 27,716 feet per hour. A speed of 3½ miles can be kept up for several hours by actuating the screw alone.

According to Mr. Jaquet, the boat is remarkably silent. The mechanism, which is exceedingly simple, is not liable to breakage. The position of the occupant is very comfortable, and he can read or fish while working the pedal. The boat performs its evolutions with the greatest ease, and can be made to move forward or backward at will, and can be turned about within an exceedingly limited space.

The sportsman can conceal himself completely and fire with the greatest ease, as both of his hands are entirely free.

Finally, as the screw can be instantly raised in the air, one can go at will by screw, oars, or sail.

This system can be adapted, without necessitating any special construction, to any sort of boat either with a keel or flat bottom. It is susceptible of more general application, and may be utilized for boats of pretty large tonnage navigating the sea, on condition that the screw be left entirely movable and held by a chain fixed by its two extremities to the breastwork of the craft, and carrying at its center the collar of the screw shaft.—*La Nature.*

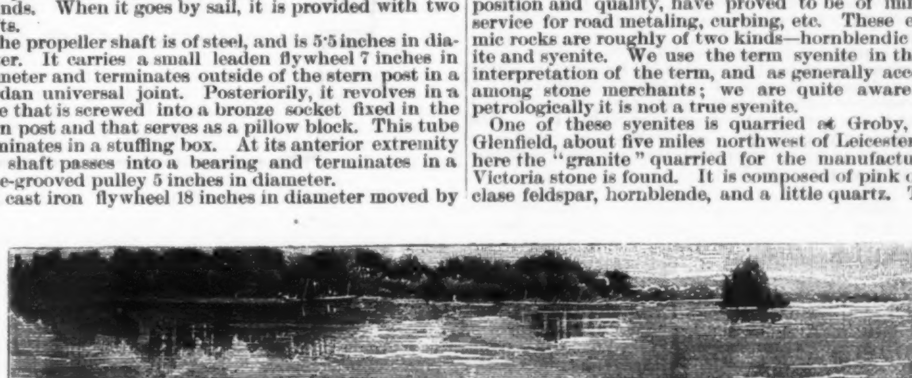


FIG. 1.—SEGUIN AND JAQUET'S NEW BOAT, CAPABLE OF BEING PROPELLED BY SAIL, OARS, OR SCREW.


FIG. 2.—DETAILS OF THE SCREW MECHANISM.

HOW ARTIFICIAL SILICA STONE IS MADE.

WE found ourselves in an immense building, 365 ft. in length and 144 ft. in width. Partitioned off from the moulding works carried on therein were the depots for storing the washed, crushed granite, which forms the basis of the Victoria stone.

In the center of England, in Leicestershire, masses of igneous rocks are found which, from their geographical position and quality, have proved to be of immense service for road metaling, curbing, etc. These economic rocks are roughly of two kinds—hornblendic granite and syenite. We use the term syenite in the old interpretation of the term, and as generally accepted among stone merchants; we are quite aware that petrologically it is not a true syenite.

One of these syenites is quarried at Groby, near Glenfield, about five miles northwest of Leicester, and here the "granite" quarried for the manufacture of Victoria stone is found. It is composed of pink orthoclase feldspar, hornblende, and a little quartz. There

is also some opaque mineral, evidently in a greatly altered condition, perhaps originally pyrites, or magnetic oxide of iron. The feldspar is in distinct crystals, but has often caught up much hornblende; the quartz fills up the spaces between the other minerals, or is curiously crystallized with the feldspar, so as to form a microscopic "graphic granite," or "hebraic feldspar."

For the purposes of the Victoria stone, the Groby "granite" is crushed so that the grosser particles are not larger than peas, and there is necessarily much dust arising from the operation. In order, however, that the crushed material shall be purged of this, and other inevitable impurities, it is carefully washed. When this operation is completed the resultant product resembles nothing so much as sharp grit. The washed material is then ready for making the stone, and it is either used at Groby—for much Victoria stone is made at that place—or it is sent to the London works at Stratford Market Station. There, as we have seen, it is carried on barges and delivered through suitable shoots from the Channelsea river.

A very important part of this process is the proper mixing of the ingredients, which consist of one part Portland cement with three parts of the crushed granite. In order that the necessary quantity of water should be employed—no more and no less—that liquid is automatically gauged; and an essential feature is the sprinkling of it on the compound in the machines, which is done in a somewhat similar manner to that from the rose of an ordinary watering pot. The steam mixers are rotary machines working horizontally from a vertical spindle, in a circular trough, and various shaped plows and devices are attached in order to turn over and thoroughly incorporate the material to be mixed.

From the mixers the compound is supplied to the moulders, who, in addition to making the paving flags, may also be employed to mould the material into sinks, coping, caps, window and door sills, landings, steps of various shapes and sizes, or other constructional purposes. In making the paving flags, the compound is delivered to the zinc-lined moulds. It is the next stage which constitutes the essential characteristic of the Victoria stone—the steeping of the material in what are known as silica tanks. After the concrete slabs are dry, they are taken out of the moulds and immersed in a solution of silicate of soda from ten to twelve days, depending on circumstances, by which process they become hardened and are better able to withstand the wear and tear of traffic.

The specific gravity of the slabs before immersion averages about 2·7, or about 43 lb. per square foot of 3 inches in thickness, or about 25 lb. per square foot of 2 inches thickness; and they are, in this state, naturally somewhat porous. The solution of silicate of soda in which the slabs are immersed is made by boiling Farnham stone—a stone, geologically, of the age of the Upper Greensand, and quarried at Farnham in Surrey—with 70 per cent. caustic soda previously made into a solution with water. The silica of the stone dissolves, and the solution is diluted for use to the required strength. The concrete slabs become impregnated with this solution, and their pores are filled with the amorphous hardened matter which results from the chemical action engendered.

The *Chemical Trade Journal* states that upon analysis it was found that the solution most suitable for the operation had a specific gravity of 1·16, and a liter of this solution contained in grammes—

Silica	106
Soda	65

which is practically seven equivalents of silica ($Si\,O_2$) to four equivalents of soda ($Na_2\,O$), the normal silicate of soda being composed of one equivalent of each. In that solution cement blocks were steeped, and it was found that even one immersion was sufficient to alter the composition of the indurating fluid. After one steeping, the liquid possessed the following composition in grammes per liter:

Silica	94
Soda	64·6

or six equivalents of silica to four of soda, one equivalent of silica having left its soda combination and gone over to the bases of the cement. A liter of the solution lost just twelve grammes of silica.

The slabs are allowed to remain in the silicating tanks ten to twelve days; they are then taken out, scoured with clean water and stacked in the yards for at least three months before being sent out for use.

The crushing weight of the material, as determined by Mr. Kirkaldy, is 8,321 lb. per cubic inch. Some of the most compact igneous rocks of the country, and such as are not used for pavement purposes, although extensively employed for paving sets. Compared with ordinary Yorkshire landings, the Victoria stone has a greater crushing strength of 2,470 lb. per cubic inch than the York stone has against the bed, and 2,705 lb. per cubic inch than when the latter is tested on the bed.

According to Mr. Henry Reid's work on concrete, the average tensile strain of 10 briquettes of the Victoria stone is 794 lb. per square inch. Recent experiments demonstrate the fact that the stone, as now manufactured, has a tensile strain of 1,125 lb. per square inch.

Rivington's "Notes on Building Construction" states that the bulk of water absorbed by the stone, as compared with the bulk of stone, was 7·6 per cent. when immersed for 24 hours.

In December, 1869, the southeast approach to Blackfriars Bridge, London, was flagged with Victoria stone, and in spite of the enormous traffic, the stone still remains, being in excellent condition. The flagging was made under the old system with coarse granite. In June, 1872, Piccadilly, from Stratton Street to Bolton Street; in March, 1877, round the "Elephant and Castle" buildings, and in High Holborn, from Great Turnstile westward; and in June, 1887, both Middlesex halves of London Bridge were all laid with the Victoria stone, and in each case the material is yet in good order.

The stone is extensively employed in large towns and cities, and the demand for it is growing greater every year. Thirty thousand square feet of slabs, two inches thick, are made weekly at the works.

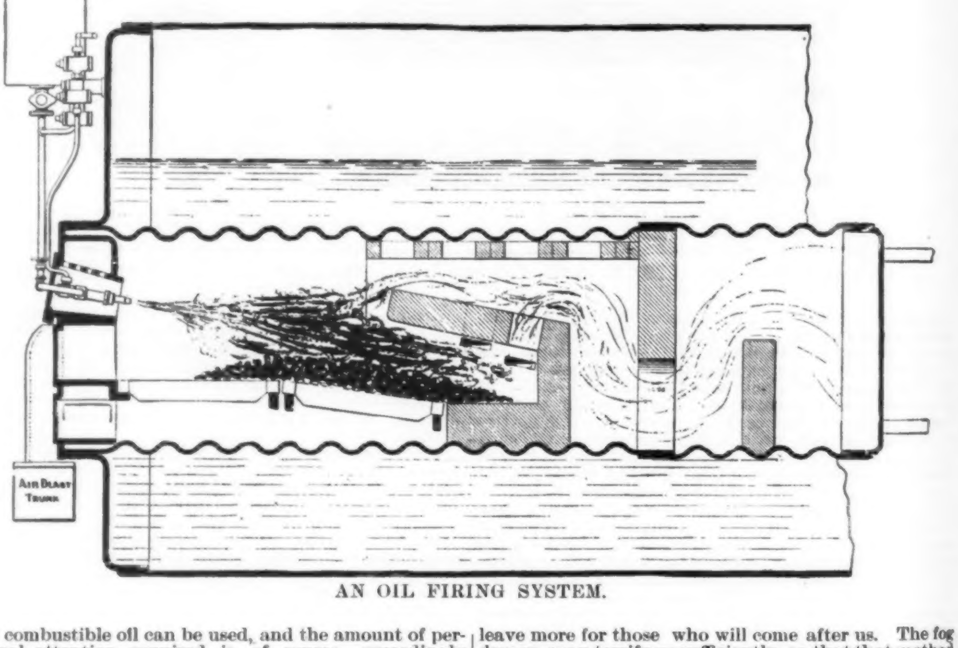
AN OIL-FIRING SYSTEM.

We illustrate an arrangement introduced by the Gaseous and Liquid Fuel Supply Company, Limited, of Manchester, for the purpose of enabling fuel to be utilized in the furnaces of steam boilers. The engraving, which is from *The Practical Engineer*, shows a longitudinal section taken through the center of the furnace; the fire grate is arranged somewhat lower than is usually the case where coal alone is burned, and the furnace mouth is entirely closed with a chambered casting, to the cavities of which air is supplied, either by means of a fan in the ordinary way, or by the adoption of one of the firm's steam jet aspirators.

When steam is raised in the first instance, a small coke fire is laid on the grate, upon which the supply of liquid fuel is distributed by means of an injector, which is of special rifled form, and situated in the fire door, the supply of air being distributed in a circular flow around the spray of oil from the cavities in the fire door, to which reference has been made, and in its passage through which it undergoes a preliminary heating. At the bridge end of the grate, a firebrick chamber is provided between the ordinary bridge and an inverted bridge placed a little behind it, while a little further beyond is a nest of checker firebrick work. The object of this arrangement is to give a more equal distribution of the heat, and also, since the brickwork soon attains a state of incandescence, to secure a more perfect combustion.

For the purpose of protecting the crown plate of the furnace from the effects of excessive temperature, a firebrick arch is placed over the latter part of the furnace, and with a view of still further reducing the strain and promoting circulation within the boiler, it is recommended that a Thwaite saddle circulator should be placed on the outside of the furnace in the water space.

It will be seen from the description given that the degree of intensity of combustion is under perfect control, and may be permitted to range within wide limits. The fire can either be shut off instantly or relighted with almost equal facility, while any character of combustible oil can be used, and the amount of personal attention required is, of course, exceedingly small, since the supply of fuel after the grate is started is practically automatic, and the heavy, laborious work of ordinary hand-stoking is entirely dispensed with. The use of liquid fuel, especially on board ship, is a matter to which considerable attention has of late been directed, and which, for the main obvious advantages it possesses, is likely before long to be much more widely adopted. The Italian government have adopted the oil-firing arrangement on a number of their torpedo boats with great success, and the subject is one well deserving attention of all who are interested in promoting a reform of the present unsatisfactory method of raising steam on board ships.



AN OIL FIRING SYSTEM.

FUELS AND THEIR USE.*

By J. Emerson Reynolds, M.D., D.Sc., F.R.S., University Professor of Chemistry, Trinity College, Dublin.

The members gave Professor Reynolds a hearty cheer when he rose to read his address. He referred to the satisfactory condition of the society, the growing membership, full income, and prosperous journals. Delicately also he touched the darker part of the year's picture. The loss, by death, of Dittmar, Heisch, Tidy, Richard Smith, F. C. Hills, Makins, Mumford, Schorlemmer, the venerable Dr. Redwood, and the illustrious August Wilhelm von Hofmann, "a teacher of teachers; the source of the primary impulses from which great industries have sprung; the brilliant investigator of some of the most difficult problems in the philosophy of chemistry; the wise counselor of princes, and the sincere friend of every lover of nature—truly a noble man!"

The presidents of the society have, in their addresses, avoided being chroniclers, rather preferring to devote themselves to the subjects of their life work. Therein was Professor Reynolds' difficulty. He thought he would ill requite the confidence of the society if he devoted his address to the abstract and philosophical side of chemistry by giving an account of his old thio-organic work or even the studies of later years in the silico-organic department of the science, as few of the products of either line of investigation are within measurable distance of practical application. He therefore proposed to take as his theme the modern developments in regard to

FUELS AND THEIR USE,

as the subject is one which has occupied much of his time and attention for many years, and links in practical interest chemical and other industries with the still wider considerations of social economy. The fuels which have to be considered are coal, peat, and petroleum. It is erroneous to suppose, as some do, that the supply of coal is inexhaustible or that the price will not become prohibitive. The president pointed out how labor combinations and increased difficulty in "winning" it affect coal on the latter point.

During the last twenty years there has been a very marked increase in the consumption of coal, in European countries alone the average annual output for the period 1881-90 being upward of 62,000,000 tons greater than during the previous decade. This rate of increase bids fair to be maintained, so that the world's consumption of coal will soon reach 500,000,000 tons per annum, if it has not already done so. How long can this supply be maintained? To answer that question, Professor Reynolds referred to the Royal Commission on Coal Supply, which investigated the matter in 1861-71, and reported the existence in Great Britain, at a depth within 4,000 ft. of the surface, of 146,480,000,000 tons, or enough for 230 years, but 170 years is reckoned a safer figure, and long before we came to the end of the supply the coal would be brought to the surface with such difficulty and at such a cost that it would be cheaper to import it. That may be the condition in fifty years, according to Mr. T. Foster Brown, and then it is North America to which we shall look for our supply, as there the coal strata are seventy times greater than ours.

But the difficulty is where to begin. Professor Reynolds was not sanguine of ordinary consumers being so interested in posterity as to prevent waste, so as to leave more for those who will come after us. The fog demon may terrify us sufficiently, so that that method of burning coal which avoids the formation of smoke at any time, and is both more convenient and economical, must ultimately "hold the field." The professor did not think that alteration of grates would effect this end, but that we must look to "gasification" of the fuel for a solution of the problem. He proceeded to describe several proposals which have been made. Thus Sir William Siemens showed that from a ton of coal he could get gas equal to 1·7 ton. That gas contained, however, 65 per cent. of useless nitrogen. The Wilson method of gasifying coal gives a richer gas—or, strictly speaking, two gases—viz., a certain proportion of "producer" gas in raising the temperature of the coal up to the point at which it can decompose steam, and then a mixture of carbon monoxide and hydrogen, or so-called "water gas." The former can be used for steam raising or furnace work in the immediate vicinity of the producer, while the water gas can be transmitted through mains as readily as ordinary town gas, and loses nothing by carriage save its initial heat.

But the difficulty comes in in application, for a gas which is good for illuminating purposes is a dear fuel, and Professor Reynolds pointed out that steam is introduced into common gas to increase the yield, whereby the illuminating power is decreased, and has to be compounded by the introduction of some rock oil gas. Professor Reynolds considered that since the supply of the richer bituminous coals is steadily diminishing, the practice must grow of supplying a modified water gas instead of coal gas as we have hitherto known it, and it would be better far that this change should be carried out with the full knowledge and assent of the public after due parliamentary inquiry, and in such a manner as to secure the maximum advantage without undue interference with the great monopolies enjoyed by the gas companies. There are many ways of insuring efficient light, and this consideration should not stand in the way of the supply of a cheap heating gas, which would prove a great boon to small manufacturers as well as to the domestic consumer. In the near future electricity will be the general illuminating agent, and with a cheap heating gas as a fuel, the fog problem will be solved, and we shall have largely done our duty to posterity by the

* Abstract from the Presidential Address before the Society of Chemical Industry, London, July, 1892.

introduction of more economical methods. The president then turned from coal to peat, a subject in which he has a large native interest, for, as he explained, one-seventh part of Ireland is bog. About 1,250,000 acres are mountain bog, and 1,575,000 acres are occupied by flat bogs. This store of peat is an asset which may become valuable when our coal beds are exhausted 170 years hence. Ireland gets her coal from Britain. In this fact we have some explanation of the depressed industrial condition of the country, as manufactures involving the use of much fuel can only flourish in Ireland if the margin of profit be considerable; where the margin is small and competition keen (as in the greater industries), they must go under in the struggle with manufacturers having cheaper fuel at command. Peat alone, however well prepared, compares very unfavorably with coal in several particulars: First, it is very bulky; second, it contains from 15 to 25 per cent. of water, and seldom less than 10 per cent. of ash; and third, at least 2½ tons of average peat are required to perform the same work as 1 ton of average Staffordshire coal, or in other words, we require of peat more than thirteen times the bulk of coal to produce the same thermal effect. Various means have been suggested for overcoming these disadvantages, and those which have involved artificial drying as well as mechanical compression have cost so much that the product could not compete with coal at the ordinary level of prices. During the coal famine of 1872, serious efforts were made in Ireland for the utilization of peat. Professor Reynolds saw then that the best chance for economically applying peat for most manufacturing purposes lay in gasifying the material in a Siemens furnace, as two special and important advantages would obviously be gained thereby: (1) the use of peat in the rough state without artificial drying; (2) the avoidance of the injurious effects of abundant ash by burning the peat gas at some distance from its source, and under such conditions that the comparative value of coal and peat should be nearly in the proportion of their percentages of carbon. He moved the Royal Dublin Society in the matter, and the Great Southern and Western Railway of Ireland took it up, using a complete Siemens regenerative gas furnace for working up scrap iron, with the result that the average consumption of fuel was 5·09 tons of peat for each ton of iron forged from scrap to finished work, where 4·96 tons of coal were required. This work remains the sole practical outcome of efforts in the direction of peat utilization. Yet the fact remains that, as in the case of coal, peat could be made economically to provide light and heat energy as well for domestic use as for manufacturing purposes. "Would that we could apply even a small portion of the energy stored up in peat to stimulate those who should be most active in utilizing in the best and most economical way the abundant material almost at their doors!" With this dig at his compatriots the president passed on to petroleum.

Sketching in broad outline the main points of public interest which relate to this, the most important of our liquid fuels, he referred to the work done by Mr. Boverton Redwood, Dr. Armstrong, Sir Lyon Playfair, and many others whose names are indissolubly connected with petroleum. Then proceeding to the production statistics, he showed that the United States furnished in 1890 45,000,000 barrels, Russia 25,000,000 barrels, and Galicia 770,000 barrels. To-day the world's production of crude petroleum may be estimated at fully 75,000,000 barrels per annum, or upward of ten million tons.

This amount does not include asphalts (which are probably petroleum residues from which the volatile liquids have evaporated), nor does it include earth wax or ozokerite. The surprising extent to which the oil industry has grown in little more than thirty-three years naturally suggests the question whether the supply will continue. We cannot make an approximate estimate of this, as in the case of coal. It is a fact that the existing large oil-producing districts do not, taken as a whole, afford material indications of diminished productiveness, notwithstanding the enormous drain upon them. Particular wells become exhausted, but new ones are bored and the output is maintained. This, however, is a process which must have its limits. Of rather greater significance is the fact that rock oils and petroleum residues have been discovered in almost every country, and it would appear that stores of the material exist at points hitherto almost untouched. Two conclusions may be drawn from this fact—viz., that there is ample provision for the near future, and that these mixtures of liquid compounds of carbon and hydrogen result from some process which is general in its operation, and which is or has been most active near to those great crumples of the earth's crust we call mountain ranges. As the United States Geological Survey puts it: "Petroleum is derived from organic matter by a process of slow distillation at comparatively low temperatures; that the organic matter was not in all cases of vegetable origin, but was in some instances derived from animal substances in contact with limestone; and, finally, that the stock of petroleum in the rocks is practically complete. It follows, of course, that the supply is exhaustible, but geologists do not even guess at its duration." In contrast with all this is Mendeleef's view that petroleum is not a product from organic material, but is chiefly formed by the action of water at high temperatures on carbide of iron, which he supposes to exist in abundance within or below the earth's crust. The cracks and fissures caused by the upheaval of mountain chains permit water to reach the heated carbide at great depths, and carbides of hydrogen result in accordance with the general equation—

$$3Fe_mC_n + 4mH_2O = mFe_3O_4 + C_{3n}H_{8m}$$

The hydrocarbides then distill up and condense within the cooler sedimentary strata. The occurrence of petroleum in active volcanic areas, as in Sicily and Japan, is held to accord with this hypothesis, which latter is also consistent with the remarkable fact that rock oil is usually found in the vicinity of mountains. Professor Reynolds' chief reason for referring to this attractive hypothesis was that it permits us to suppose the hydrocarbides are still being formed within the earth's shell, especially beneath the geologically modern mountain chains, and that the supply of petroleum is practically inexhaustible. Whether that view can be sustained we must leave further evidence to decide.

NATURAL GAS.

The president's next topic was the gas wells which exist in the American petroleum fields, and which are the cause of so many explosions or eruptions when lucky borers strike oil. Some of the wells afford from 10 to 14 million cubic feet of gas per day, delivered at a pressure of as much as 400 lb. to the inch. The gas is a fuel of high value, and has been largely utilized for industrial and domestic purposes at such industrial centers as Pittsburg. One million cubic feet of the natural gas obtained from the Trenton limestone at Findlay, Ohio, are said to do the same amount of work in heating as about 60 tons of Pittsburg coal. Some of these gas wells have been exhausted; others have continued in full productiveness for several years, but they remain of almost exclusively local value. Not so liquid petroleum, which is the most portable of all fuels obtainable in nature.

GASIFIED PETROLEUM.

The hydrocarbides of American petroleum belong to the saturated group C_nH_{2n+2}, whereas those of Russian petroleum are mainly benzenoid hydrocarbides of the general formula C_nH_{2n} isomeric with the olefines, but really hydrogenized aromatic compounds of the naphthene series. Petroleum from both sources affords some of the lower homologues of marsh gas—hence in the process of refining crude petroleum by distillation the first products consist largely of butane, pentane, and hexane, which are separated and condensed by pressure, the product being used for refrigerating purposes, owing to its high volatility. Between 80° and 120° American petroleum affords a spirit of specific gravity about 0·75, and above 130° the illuminating oils are obtained, whose gravities vary about 0·8, while the residue which is not vaporized at 300° includes the heavier lubricating oils, which are also admirably suited for use as fuel, and are cheaper than those generally used for lighting purposes. During this process of refining by simple distillation there is always more or less decomposition in progress, hydrocarbides of high molecular weight being resolved into simpler ones at a comparatively high temperature; and when crude petroleum or its constituents are rapidly heated, this resolution can be carried so far as to convert a large proportion of the oil into permanent gas, valuable alike for illuminating and heating purposes. The president proceeded to discuss at some length the investigations which have been made during recent years into the production and properties of this permanent gas. He maintained that the results justify his statement that petroleum is a liquefied gas, which differs, therefore, very greatly from coal and peat, for petroleum can be used as an illuminant as well as a fuel, whereas coal and peat can only be used as illuminants in so far as they can afford carbureted gas. Further, he asserted that petroleum is the most concentrated and portable fuel. In proof of this he advanced statements deduced from experiments. First—weight for weight, petroleum evaporates twice as much water as coal does. The particulars are: Refined petroleum 1 lb. evaporated 12·02 lb. of water; 1 lb. poor steam coal evaporated 6·5 lb. of water. Crude petroleum and Pittsburg coal gave respectively 15 and 7·2 lb. of water per lb. of fuel. Professor Unwin compared petroleum with Welsh coal, and found that 12·16 lb. of water were evaporated per lb. of petroleum, or about 25 per cent. better than that afforded by the steam coal.

Petroleum has an advantage over coal in the matter of storage, as one ton of the liquid occupies only four-fifths of the space of the same weight of coal, so that a steamer constructed to carry 1,000 tons of coal could, if provided with suitable tanks, carry 1,200 tons of petroleum, equal in fuel value to about 1,900 tons of coal. As to the matter of cost, although at present petroleum is the dearer, a comparatively small advance in the price of coal would at once render heavy petroleum economical for industrial use as fuel, while the present prices of the lighter petroleums indicate that they are the cheaper fuel as well as illuminant when gasified. Therein is the point of the whole address. If we desire to use each fuel (coal, peat, or petroleum) in such a way as to develop most economically and conveniently its store of heat energy, we must first partially or perfectly gasify it, and petroleum is the one which lends itself most easily and completely to such treatment.

[From Jour. Phot. Society of India.]

HALF-TONE PHOTO-BLOCK PRINTING.

By Colonel J. Waterhouse, S.C., Asst. Surveyor-General of India.

The problem of breaking up the continuous gradation of the photographic image of half-tone subjects, so as to render it suitable for various methods of press printing, was one which exercised the ingenuity of photo-mechanical printers for many years; but so far as photo-block printing in half-tones is concerned, nothing really practical was done till Meisenbach, of Munich, brought out his so-called "autotype" process, in which the image was broken up by a series of lines crossing each other at right angles or thereabout, and forming a number of dots and spaces varying in size and nature according to the depth of shade in various parts of the picture. The use of lined screens and network of various kinds for this purpose was not by any means new; but, whereas, in most of the earlier methods proposed, the photographic image was merely cut up into small spaces by a network, or broken up by the wrinkling of a gelatine film, in Meisenbach's method there was a distinct independent gradation given to the image by the cross lines or dots being of different thicknesses, corresponding to the gradation of the picture. This was an enormous advance, and although the actual methods of employing the ruled screens in use by different operators following Meisenbach's system may vary, the principle of obtaining this gradation by diffusion or diffraction is the same in all, the amount of it being regulated by the distance of the ruled screen from the original or from the sensitive plate and the amount of light passing through it, as well as by the relative proportion of opaque line and clear space forming the ruling.

Very little is known of the details of the various processes employed by European or American photo-block etchers, and so I propose to confine myself to the process we have followed here in Calcutta, which will stand comparison with much of the work done elsewhere, though not yet equal to the best, and may have some points of originality to commend it. It is based on the ordinary intaglio photo-etching process followed in Survey of India office, and has been worked out by my assistants, Mr. A. W. Turner and Mr. J. T. Meade, under my supervision, and has the great advantage of not requiring a reversed negative. The first necessity is a good ruled screen. We originally tried reproducing some special printed crossed lines I obtained from Europe. These did fairly well, and had the advantage of allowing screens of varying closeness to be easily and cheaply prepared from one ruled original, but it is very difficult to secure evenness of tint and freedom from spots and defects which mar the beauty and perfection of the screens, and consequently of the images produced from them. Some trials were also made by Mr. Turner in the office of ruling screens on sheets of plate glass evenly coated with India rubber dusted over with fine plumbago, which gives a very opaque film easily cut with a point in the ruling machine. While in Europe last year I obtained from America some glass ruled screens from two makers, one of whom produces his screens direct on glass, and the other by photography. Both of these kinds of screens have given much better results than anything we had tried before, and with one of the finest screens ruled on glass—150 lines to the inch, which Mr. Levy kindly sent me for trial—the process seemed to go almost automatically.

The usual way of using these screens is to place them in front of the sensitive plate, leaving a small space between, which may either be fixed or varied according to the subject to be reproduced; or the screen may be placed in front of a transparency of the subject to be reproduced and a negative made in the copying camera. I have not yet been able to go into this subject myself, and so can say little about the best method of using the screens, and the effects that may be produced by various ways of working. The subject is a very interesting one, and I hope to be able to say more about it hereafter. The negatives are usually taken by the wet collodion process, as giving the clearest and sharpest results, and have to be intensified in the same way as ordinary black and white negatives, so that the blacks may be nearly opaque and the clear spaces as transparent as possible. The best way of doing this is with copper bromide and silver nitrate, followed, if necessary, by treatment with hydrosulphate of ammonia.

The negative should show an image in good gradation, but broken up into a network inclosing small points, varying in size and character according to the amount of exposure received in different parts of the film. In the darkest parts of the negative, which represent the lights or white spaces of the finished print, these points have the appearance of small transparent dots joined by opaque spaces; and as the negative increases in transparency, corresponding to the increasing depths of shade in the print, the transparent dots increase in size and the opaque spaces decrease, till in the deepest shadows the distribution of light and shade in the dots and spaces is quite reversed, and the negative image is formed by very small opaque dots joined by transparent spaces, and finally, in the deepest shadows of all, by complete transparency.

Having obtained a good grained negative, the rest of the process is very simple. The image may be etched on copper or zinc plates in various ways, using either a thin film of asphalt or of bichromated albumen, etc., as the sensitive surface. It must be noted, however, that if the image is printed directly on the metal surface, a reversed negative will be required. Zinc plates seem to be ordinarily used for these blocks and offer more facilities for deep biting when necessary; but we have found thin copper plates in many ways more convenient, and we make them easily for ourselves by electrotyping from a highly polished copper plate. The plates we use are about the thickness of a stout card, quite flexible, and can easily be cut with shears.

The first thing is to fix a fine dust grain of powdered asphaltum upon the clean polished surface of the copper plate, just in the same way as is done for the ordinary intaglio photo-etching process. The grain should be very fine, so as to be eaten away during the etching of the image, but just suffice to hold down the gelatine image. A print is now taken from the grained negative upon the ordinary standard brown autotype tissue, transferred under water to the prepared thin copper plate and developed in hot water in the ordinary way.

A quantity of prints may be developed upon the same plate and etched together or separately, according to the requirements of the various subjects. The pigment prints should be made in sunshine, and require an exposure of about two minutes. After development, the images are dried off in the usual way with spirit of wine, and parts not requiring to be etched, as well as the back of the plate, are painted over with asphalt varnish to protect them from the etching fluid. Before etching, the prints should be carefully examined to see that there are no defective parts, and especially that the grain is crisp and sharp; the slightest want of contact in the printing frame will spoil the result.

The copper plate bearing the gelatine image is now placed in a solution of perchloride of iron at 44 degrees Baume, and the process of etching is carefully watched, the biting being allowed to continue for ten or twelve minutes, after the first signs of action, or until the greater part of the image is etched; the plate is then placed in a weaker solution of perchloride at 40 degrees Baume and left in this for another six or eight minutes, until every part of the image has been eaten into the copper except the deepest shadows. The gelatine image is then washed off in a strong current of water, and the plate cleaned with ammonia and chalk.

If the etching has been properly carried out, a perfect image in relief will now be obtained, with every line and dot of the grained negative reproduced clear and sharp. On advantage of this mode of etching is that the grain is not underbitten; the finest lines and dots are always perfect, because, if the finer parts should be over-etched, the image is attacked by the perchloride on the surface without removing the gelatine film, as would be the case in etching an image in

asphalt or fatty ink. The result is that the lights of the picture are slightly below the level of the deep shadows, but not sufficiently so to interfere with the printing; in fact, this may assist it by causing the deeper shadows to take up more ink than the lights, and so form a natural, graduated method of overlaying, so important in typographic printing. The plate now obtained, though fairly deep, is not sufficiently so for printing purposes, and recourse must be had to rebiting, which is the most important and delicate part of the process. For this purpose a hard gelatine or smooth rubber roller should be used, and the image is very carefully rolled up with an ink composed of good lithographic ink and black wax thinned down with sufficient lithographic varnish to just make it workable on the slab, the ink being as hard as possible. The black wax composition is similar to that used for making electrotyping moulds, and is made of—

Spermaceti	56 parts.
Stearic acid	26 "
White wax	24 "
Asphalt	9 "

melted together.

With due care, the image is easily rolled up with this composition, and it forms such a powerful resist to the etching solution that a very thin film will be found sufficient to protect the image. After rolling in, the plate is slightly warmed over a gas stove and the back of it and the margins of the picture again painted over with asphalt varnish. It is then put into a 38 degree Baume solution of perchloride of iron, and should stand about two minutes' etching; this will deepen the image considerably, but may have to be repeated a second and sometimes a third time before sufficient depth is obtained, care being taken that between each biting the plate is thoroughly cleaned with turpentine and benzole.

A great deal can be done with the plate to improve it during the process of rebiting by painting out and biting only such parts of the plate as may require it; but this depends upon the requirements of the subject and the skill of the operator.

When the etching is quite finished, the plate is cut to the size required, leaving, as a rule, a narrow black line or border round the subject, and it is then ready for mounting.

Mr. Turner has adopted an ingenious way of doing this, which may be novel. The copper plates, being very thin, are fastened down to blocks of wood, type high, with strong bichromated gelatine, and hold exceedingly well, though zinc plates treated in the same way do not seem to hold so well. The back of the plate is first carefully cleaned with turpentine, and afterward with a strong solution of caustic potash, in order to free it from all traces of greasy matter which might prevent adherence. It is then dried and a sheet of white tissue paper is attached to it with a solution of—

Gelatine	8 parts.
Potash bichromate	1 "
Water	32 "

Upon the wooden block a sheet of thin drawing paper is attached with the same solution. The tissue paper on the back of the plate and the paper on the wooden block are now thickly coated with the bichromate solution, and the two surfaces brought into close contact with each other and placed under pressure. A piece of oiled paper is laid on a sheet of thick glass, and the blocks laid face downward upon it; a number of sheets of thick plate glass are then piled on, and the whole left till the next day, when it will be found that the copper plates are firmly attached to the wooden blocks and quite level. A proof is then taken and, if necessary, the typographic images can be touched up with a roulette or graver to bring out lights, or with a burnisher to deepen shadows.

The printing of these blocks seems to offer no great difficulties, provided the wood does not warp and the surface remains level. The image, being broken up all over into a series of minute dots and spaces, offers a good support for the roller, and the images generally print very sharp and clear. The quality of the paper has, however, a very great influence on the result, and the best impressions are obtained on highly glazed paper.

Eder's *Jahrbuch* for this year contains two illustrations printed from the same block by Meisenbach, one on the highly glazed paper being of a rich full tone, and almost as perfect in gradation of light and shade as a collotype print, while the other, printed on ordinary paper from the same block, is poor, flat and spotty. Enameled paper, as used for collotype, also gives good impressions, but they are easily damaged. There does not seem to be the same necessity for overlaying as with ordinary deep-cut blocks, though it is probable that a skillful use of this auxiliary might aid in producing the finest results a block would be capable of giving.

PROTECTING DYNAMOS.

By FORKE BAIN.

A LIGHTNING arrester that does not arrest is like an inefficient police officer; and there are a great number of lightning arresters of this type. An old style device which has always been successful with a few exceptions, in telegraphing, is the saw tooth plates; one connected to ground and an opposite one separated only a fraction of an inch and connected to line. Lightning will crack through this simple device a dozen times a day and do no harm. Combs would work just as well on an electric light circuit if it were not for the fact that the powerful current of a dynamo will follow the lightning arc across the combs and thus short-circuit the dynamo. A fuse between the ground comb and the ground will prevent any dangerous results. But it frequently happens that several flashes come in rapid succession, and in such a case the second flash would not go to ground over this path because of the long gap where the fuse melted away. Efforts have been made to produce an arrester that would substitute fuses, but in most of these devices a single flash seldom fails to blow all the fuses. It is unnecessary to designate the various devices that have been called lightning arresters, and are still being sold under that false name. I will say, though, that I have records where most of them have failed.

Fig. 1 illustrates a device, however, which will be found more reliable than most of the fancy finished machines that do not arrest. Leave your old saw tooth plates as they were and take out your fuses. Substitute instead a tin or iron bucket, a couple of powder kegs each with one head out. Sink these kegs in a bed of charcoal or coke under the eaves of your engine or dynamo room. Connect these vessels together and to a good ground, gas or water pipe, by wire. Take the ground wire for the circuit to the bucket and let it dip down about half the way to the bottom. Now fill the

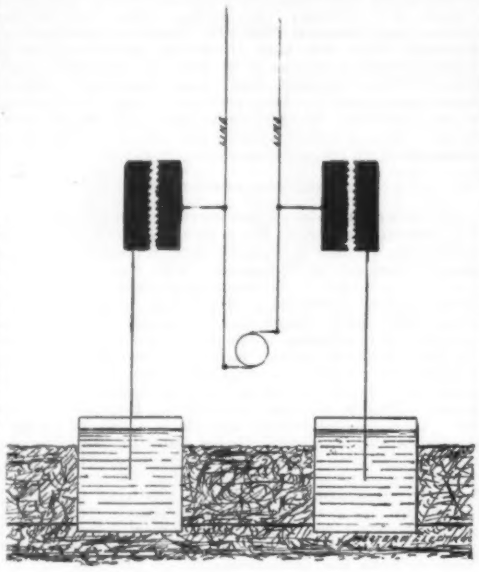


FIG. 1.—PROTECTING DYNAMOS.

kegs with water, and keep them filled. A bucket for each side of the circuit will be required. I have known this device to be in use for several years without any disastrous results from lightning. The only objection to it is that the buckets or vessels must be kept filled with water.

Static electricity, produced by rapidly traveling belts, especially on cold, crisp days in winter, is very annoying and dangerous. I have seen a well insulated dynamo standing idle become charged as a condenser, to such an extent that it would knock a man down when he touched it. Had this machine been thrown suddenly into circuit, the discharge would have caused an arc to ground and produced, no doubt, a burn-out, just as lightning would have done.

I have found a very efficient device to completely and thoroughly protect dynamos and underground cables against damage resulting from static electricity. As the device costs little or nothing, it can be easily applied and is worth trying.

Fig. 2 represents the static preventer. It consists of a piece of vulcanite with a screw and two copper washers at each end. The piece of vulcanite should be 7 inches long by 1 inch wide and ¼ inch thick. Paste a

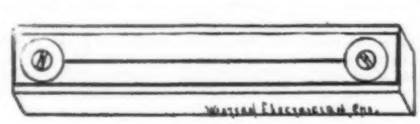


FIG. 2.—PROTECTING DYNAMOS.

piece of semi-calendered writing paper under the screws and one side of the vulcanite, draw with a soft lead pencil a line as indicated from one washer to the other. The line should be carefully drawn, so that electric continuity between the washers is secured. This lead pencil mark will measure several megohms, but it will prevent an accumulation of static charge. Connect the frame of each dynamo to the ground through one of these devices, also connect each side of the circuit to ground in the same way. If there is any lead cable in circuit, locate one of these devices in a dry place and connect the copper conductor of the lead cable through the pencil mark to the ground. This simple little wrinkle will prevent many burn-outs from so-called "mysterious causes."—*Western Electrician.*

FATAL RESULT OF WATER DRINKING.

AN old way of poisoning criminals used to be to compel them to swallow large quantities of bull's blood, and it is (the *Lancet* says) interesting to note how this acted as a means of causing death. Bull's blood is not a poison at all in the ordinary sense of the word; but when it enters the stomach it forms a coagulum and, instead of the organ being filled with liquid which might be ejected by vomiting, it is filled with a solid mass. This mass presses upward upon the heart and displaces it. The pressure upward upon the lungs interferes with the respiration, and the pressure backward upon the aorta, vena cava and the solar plexus would probably be sufficient to cause death. The same thing occurs in animals when they are first turned out among the clover; they overeat themselves, and are very likely to die from overdistension. Generally death cannot be brought about by the simple drinking of fluids, because the stomach is able to eject them. Apparently, however, this is not always the case. In one of the lay papers a few days ago there was a notice of three Frenchmen who laid a wager as to who would drink most water, and all three of them died in a comparatively short time. The death in this case might have been partly due to the distension of the stomach and partly to the effect of the water on the blood after its absorption. It very rarely happens in a healthy person that enough water can be absorbed to cause any alteration in the blood, because it is excreted as rapidly as it is absorbed and the composition of the blood is kept nearly constant.

[NATURE.]

THE BEARING OF PATHOLOGY UPON THE DOCTRINE OF THE TRANSMISSION OF ACQUIRED CHARACTERS.

FOR more than two years the English public has been in possession of an excellent translation of sundry of Weismann's more important essays.* The object of this paper is not to expound Weismann's views generally. That office has already been undertaken by the persons best qualified to perform it.† We propose merely to discuss one of his topics under a single aspect—the "Transmission of Acquired Characters" in its relations to pathology.

We cannot, however, avoid reviewing some of the leading points in Weismann's system which bear upon our immediate topic.

At the root of the matter lies the all-important distinction between reproductive and somatic cells. Saving among the lowest forms of animal life, an organism may be regarded as made up of two parts. There are the reproductive cells. With these the future of the species lies. They are the visible basis of its perpetuity. The remaining tissues of the body are styled "somatic." It is natural to us to think of the "somatic" tissues as something higher and nobler than the reproductive cells—to contrast the simplicity of the latter in structure and endowment with the intricacy of the former. But there is another point of view, which inverts matters; which regards the somatic tissues—the body and its manifold endowments—simply as a sort of living case or appendage of the reproductive cells. The reproductive cells look after the perpetuity of the species, the somatic cells look after the reproductive cells.

Now, if we travel back to the simplest forms of animal life, we lose sight of this distinction. The principle of differentiation of labor is not yet recognized. Among the protozoa the distinction between reproductive and somatic cells has no place. Every part of the organism has it in its power to reproduce the entire organism. No special material is reserved to serve the purposes of reproduction. As we ascend in the scale of animal life, differentiation of labor begins. There is from the outset a reservation of reproductive cells, which serve as the demonstrable links between successive generations of organisms. But in sundry of the highest forms of animal life a third condition obtains. There is at the outset no reservation of cells; differentiation overtakes the entire organism—there is no exemption.

Not till the close of embryonic life do the reproductive cells appear, and when they do so it is as the offspring of somatic cells. This third condition was felt by Weismann as a difficulty, and led to an important modification in his terminology. The problem he had to explain was this: How can cells which have apparently lost their reproductive characters afterward regain them? The solution he found was that the differentiation undergone by certain cells was never in reality thoroughgoing enough to deprive them of their original characters. Sooner or later a moment arrives at which the original "germ plasm" becomes again predominant. Instead, then, of in "germ cells," the basis of perpetuity of the species is laid in "germ plasm."‡

We have now to consider the bearing of these views upon the doctrine of the transmission of acquired characters.

It is of the utmost importance to understand precisely what Weismann means by the term "acquired character." Acquired characters are opposed to original characters. To grasp the distinction we are sent back to a time before the distinction between reproductive and somatic cells existed. The characters already present at this early period are original characters. Later on, the reproductive and somatic cells part company, to follow separate careers of their own. It is the somatic cells—the body—which comes chiefly into collision with the environment, and in doing so undergoes various modifications. Now these modifications are the "acquired characters" the transmissibility of which Weismann denies.

They may be something purely local, as a scar or a mutilation. They may be something which involves the modification of complex musculo-nervous mechanisms, as in delicate manipulations and tricks of skill, such as violin playing. Now, how is it conceivable, he argues, that such specific changes in the somatic tissues should influence the reproductive cells in the same direction? Whether they influence them at all is not the matter in dispute. That they do this is not only conceivable, but highly probable. But how can the somatic cells stamp their own special characters upon the reproductive cells?

We now turn to the main topic of this paper. Has pathology anything to say, either for or against the transmissibility of acquired characters?

Now, as to the transmissibility of sundry forms of disease there is no question. That pathological characters are transmitted is universally allowed. The difficulty, however, is to decide whether such characters were really acquired, in the strict sense in which Weismann uses the term. We shall find that it will require considerable care to adduce instances which are really appropriate. With this preliminary caution we may proceed to attempt some sort of preliminary classification of our pathological data. We shall find that they fall, roughly, into three main groups:

(1) Morbid characters which are obviously acquired by the organism, and as obviously transmitted. But since they are in no sense the acquisition of the somatic cells as such, but of the entire organism—somatic and reproductive cells alike—they cannot be allowed to "rank."

(2) Morbid characters in which an element of transmission is obvious, but where a closer investigation re-

* Translation edited by E. B. Poulton, Schonland, and Shipley.

† Prof. Moseley's two articles in *Nature*, vols. xxxiii. and xxxiv. Discussion introduced by Prof. Lankester at the meeting of the British Association, 1887.

‡ See Weismann's essay on "Foundation of a Theory of Heredity," *passim*.

veals the fact that, supposing them to have been acquired, in Weismann's sense of the word, it is not precisely what was acquired that is transmitted, but something broader and more general.

(3) The cases which are really in point: morbid characters which were really acquired by the somatic tissues alone. We shall see, later, whether or no these are transmitted.

(1) This group embraces all those cases in which a morbid character is acquired by the entire organism, somatic and reproductive cells alike. Behind the distinction between somatic and reproductive cells lies the fact of a common relation to the circulatory and nervous systems. Any change, therefore, in the circulation for example, will affect both. A pregnant woman takes a fever, and transmits it there and then to her offspring. There is no more mystery in this than in the fact that certain poisons produce abortion—indeed, the *materies morbi* is a poison in either case. But this explanation has, in all probability, a much wider range than the zymotic diseases. Consider, for example, gout. In a sense it is no doubt true to say that gout was an acquired disease. We can point to periods in the world's history in which gout was conspicuous by its absence. We can trace with some degree of accuracy its rise and progress at different epochs, and point to the conditions under which it rose, as, for example, in the early days of the Roman empire.*

But even if we allow that gout was, in a general sense, an acquisition of civilized society, we have only to reflect on its pathology to see that it could never have been acquired in Weismann's sense. For what is gout? People usually think of gout by one of its manifestations—inflammation. This, however, is in reality no more than a symptom—perhaps than an incident—of a condition. The gouty attack is due to the existence of certain sites in the system conveniently cool and dry for the deposition of what are popularly known as chalk stones, if, indeed, it be correct to think of the morbid process as a deposition. The general morbid condition lies deeper, and still eludes us. But if we are in the dark as to the precise nature of the pathology of gout, it would be affectation to say that we are unable to prescribe its general outlines. Is it a degeneration, in which the entire organism shares? Then it will be a morbid acquisition of both somatic and reproductive cells alike. Or is it a failure in metabolism generally? The same will be the case. Or is it due to a failure in some particular gland to elaborate the materials brought to it, or to do its share of excretion? If so, the mischief will immediately make itself felt in the circulation, and the conditions of the sufferer will become practically those of slow self-poisoning. So that on no hypothesis can we represent gout as an acquisition of the somatic cells exclusively.

It is the element of progressive heredity which makes the hypothesis of transmission of acquired characters an attractive one in a disease like gout. This element is, in the case of certain families, strongly marked. We even see children suffering from the disease. And bearing in mind what we know of its ætiology, we naturally say to ourselves, "It was not this child's fault that he was born gouty. 'The fathers must have eaten the sour grapes,' or in this case, perhaps, have drunk the sweet ones." But it needs but a moment's reflection to convince us that the element of progressive heredity, so far from being an anomaly, is deducible from the facts of the case. It is true that here we cannot directly apply the theory of natural selection. We are not now concerned with conditions of progress, but with those of regress. Nature selects the fittest. There is no reason why she should select the goutiest. The question we have to ask in disease is not whether Nature selects, but whether she summarily rejects. If she stepped in and exterminated the gouty, she would stop gout altogether, and with it the feature of progressive heredity. But there is no reason to suppose that, as a fact, she does anything of the kind. In the first place, gout is not a disease which seriously shortens life; in an advanced stage of civilization its existence is quite consistent, not merely with life, but with the active discharge of elaborate duties.

But there is another more important consideration. Strange as it may sound, there may be good reasons for supposing that Nature, so far from rejecting, might even select, the goutiest. For gout, like other diseases, is only one corner of a much wider question. Diseases have coincidents and relations which stretch beyond the bounds of pathology, and trespass upon biology. This, indeed, is a side of clinical study which has only comparatively recently received its proper recognition.

In former days men contented themselves with observing the morbid symptoms of a gouty patient; they paid no regard to his other "points"—his nails, his teeth, his intellectual endowments. But it may often happen that morbid characters have their good affinities. This is probably the case in gout. We have heard it said, for example, by one of wide experience in this disease, "No gouty person is a fool"—a statement which derives some support from the number of eminent men who have been the subjects of this disease. It is often implied that in what is termed an "artificial" civilization natural selection ceases. Might we not, perhaps, say that it still proceeds, only upon a modified plan? The conditions of the competition for existence have altered. The fittest in one generation need not be the fittest of another. Thus, in a rude state of society, in which sustained physical strength is the one thing needful, the gouty man would have no chance. His enemies, however inferior they might be, would have nothing to do but to lie by for the next attack of gout, when they would easily kill him. In a more advanced state of society all this is changed. If the gouty man has talents, he probably has friends and money. There is no demand for sustained physical strength. If he has the gout, he can be nursed. His gout may be even of advantage to him—he gets into the papers. So that, paradoxical as it may seem, Nature may even select the gouty, not for their gout, but for their biological equivalents.

We have shown then that Nature, so far from interfering to exterminate the gouty, might even select them. But a more plain and obvious reason exists for the progressiveness which we sometimes observe in gout. If gout be a modification of the system generally, if its progressive increase in the tissues of a gouty patient with increasing years is in some cases a matter of observation, it would only be reasonable to infer that the same is true of the reproductive cells. For, if they share in the degeneracy, why should they not share in the progressive tendency? In the light of this consideration we can explain a fact widely received among medical men—that the incidence of a gouty inheritance falls mainly upon the younger children. Since the reproductive cells as well as the somatic grow goutier and goutier as age advances, the later their separation occurs, the more likely will they be to manifest gout.

(2) The second group includes cases in which there is an undoubted transmission of morbid characters, but where it is by no means certain that they were "acquired" in the sense under discussion. But even if they were, it does not seem that what was acquired is transmitted, but something broader and more general. We shall take as examples two important diseases—phthisis and "new growths"—alluding briefly to the phenomena of "short sight."

Phthisis may be said to be in one sense, like gout, a disease acquired by civilized humanity. "The naked savage," writes Dr. Andrew in 1884,* "whatever ills he may have to bear, rarely reckons phthisis among them; with every addition to his clothing and the comfort of his tree or cave, proclivity to it increases"—a statement which is fully borne out by what we know of the spread of phthisis in the Rocky Mountains and the islands of the Pacific. If we know less of the history of the rise and spread of phthisis than we do of gout, we have more definite conceptions regarding its pathology. At the present day that pathology may be said to have two sides. There is the side originated and elaborated by Koch—the demonstration of the constant presence of a vegetable parasite in the tissues in this disease. There is the chemico-physiological side. Before Pasteur's time, such terms as "medium," "soil," as applied to the human organism, were little more than metaphors, while such words as "constitution," "predisposition," had little more than a metaphysical value. At present, scores of workers are busily engaged in translating these terms from the language of metaphysics into their chemical and biological equivalents.

If, then, phthisis was originally acquired, what was it that was acquired? It would seem that we can take our choice between saying that the microbe was acquired, or a habit of body favoring its growth. Supposing, then, the acquisition to have been no more than the lodgment of a parasite in the tissues, can we suppose that it is the parasite which is transmitted? Our facts will hardly warrant such an assumption. How, for example, could we interpret such familiar incidents as the following: A mother, after giving birth to several children, who successively fall victims to phthisis in young adult life, is ultimately attacked herself by the same disease, at a date removed by an interval of several years from the birth of the last phthisical child. Here we should be driven to assume, not in the case of the mother alone, but in each of the several children, a long latent period, during which the parasites, though present in the tissues, made no sign. Such an assumption presents great difficulties. Again, the direct transmission of tuberculosis from a mother to her fœtus is admittedly rare, whereas on the supposed hypothesis we should expect to find it common.†

But if it is not the parasite that is transmitted, what is transmitted? We are driven back on the "other side" of the pathology of phthisis. But if we suppose that the transmission is not one of a parasite, but of a "diathesis," or "predisposition," then we desert the only standpoint from which there is any chance of proving that the disease was acquired in the sense under discussion. For what reasonable ground could we have for restricting this "predisposition" to the somatic cells alone, to the exclusion of the reproductive cells?

On the hypothesis that the thing transmitted is a "predisposition," we can, as in gout, explain the element of progressive heredity in phthisis. For, the admission of a morbid change once made, the difficulty is not so much to explain its progression as its arrest. In certain consumptive families we have in the limits of a single generation this morbid progress going on under our very eyes. It is the rule to find in such families, where several brothers and sisters are attacked, the younger fall victims at an earlier age than the elder, showing in this way their increasing liability. The explanation is probably identical with the one suggested in gout. The entire organism of the parent becomes more and more phthisically disposed—somatic and reproductive cells alike. The later the separation of the latter occurs, the more likely will they be to manifest phthisis.

The same line of argument is applicable to the facts of "short sight."‡ Short-sightedness is certainly hereditary—it runs in families—but that does not prove that we have in it an example of the transmission of acquired characters. For in the first place it would be very difficult to prove that the short sight was in the first instance acquired in the sense under discussion; while the progressiveness of the morbid character—which seems to support the theory—can be as well explained without it. For if there is no proof that the morbid character—the faulty build of the eye—is itself progressive, there is good reason to suppose that the habits of close attention which minister to the defect are so. In one generation we find a man simply tasking his eyes; his son works with a simple microscope; his grandson with an improved microscope.

I pass on to consider another group of pathological facts, of the highest importance and interest—new growths. The element of heredity doubtless obtains here as in the case of gout and phthisis. Thus the statistics of Sir J. Paget in this island and those of Velpeau on the Continent agree in showing that heredity can be traced in about one-third of the entire cases of cancer.§ And among the benign tumors, as they are called, warts and exostoses are hereditary. Further, there is in some cases evidence of progressive heredity, the irregularity appearing in the children at an earlier age than it appeared previously in the parent. And we have here what might look at first sight more like a real transmission of acquired characters than anything we have yet dealt with. No one questions that something is transmitted. The theory of the local origin of the new growths is gaining ground everywhere, and might appear to carry the inference that they are acquired, and that no constitutional element is involved in them. Here, however, we must be on our guard against the fallaciousness of words. If by constitutional we mean something pervading entire organism—a taint in the blood, and so forth—then there is little or no evidence to warrant our calling new growths constitutional. But if we mean, on the other hand, something which was represented in the original germ—an error in the original plan, not a supervening flaw—then there is nothing to encourage us in denying, and a good deal to warrant our asserting, their constitutional origin. However, such an admission is not necessary to our present purpose. Let us assume that they are acquired in the sense in which a scar is acquired. Is it a fact that what is acquired is transmitted? If so, we should look for identity in position and histological character in the thing transmitted. But on the whole neither of these conditions is fulfilled. Certainly they are not in the case of cancer, as the analysis by Mr. Morrant Baker* of 103 of Sir J. Paget's cases clearly shows. The distribution of the cancers proper shows a variation within certain limits. There is a strong predilection for certain sites, but these sites are sufficiently numerous. Now, it often happens that, where several children inherit cancer from a parent, the growth appears in each case in a different site. Nor are the precise histological characters of the growth at all faithfully preserved in the course of transmission; while it has been often observed that on the bodies of cancerous people innocent growths exist as well.† So that the inheritance does not appear to be a liability to a peculiar modification in a certain part, but a tendency to one or more of a group of modifications in one of many possible sites.

Once more we find ourselves driven to a choice between two alternatives, either of which excludes the transmission of acquired characters. For if new growths are really acquired characters, then it is not exactly what is acquired that is transmitted, but something broader than it. If, on the other hand, they are only acquired in a more general sense, they fall outside the limits of Weismann's sense of the term "acquired character."

(3) There remain for our consideration the third and, in one sense, the most important, group of pathological data—those which answer to the qualifications of acquired characters in Weismann's stricter usage of the term. Here, if anywhere, would be the ground in pathology to select for proving the theory of the transmission of acquired characters; but it must be confessed that this is just the region in which that theory receives the least support. This group of pathological facts embraces a number of accidental lesions, such as scars and mutilations, which are certainly acquired in the strictest sense of the word. But the evidence for the theory seems strong only in the dubious cases, weak in the unexceptionable ones. We have examples of mutilations practiced for many centuries by entire races, without being transmitted in a single instance. Nor is it the experience of surgeons that scars and mutilations which are the results of operations are ever transmitted. On the other hand, we have histories of tailless cats and hornless cows. But here everything turns upon the comparative certainty with which we can prove that the initial lesion was really in the first instance acquired. Have we here to do with an accidental lesion or a deformity? A closer investigation has, in many instances, rendered the latter the more probable explanation of the two. For example, in the case of the tailless cats, closer research made it appear that the irregularity involved an abnormality affecting many of the lower vertebræ. In other cases, the abnormality of the child was so little like that in the parent as to suggest that it was a merely accidental coincidence of two different lesions in one site.‡

If we turn to the results of experimental research, we are confronted by more than one remarkable series of experiments, upon the bearing of which it is impossible as yet to pronounce decisively. The most notable work done in this direction is, perhaps, a series of experiments upon guinea-pigs, undertaken by Brown-Séquard, and repeated by Westphal.§ They produced epilepsy in a number of these animals by various methods—section of the cord, section of different nerves, etc.—and observed subsequently that certain of the offspring were epileptic too.

But there are several reasons which prevent our accepting these results as decisive. The records of the experiments are said not to be very perfect. Then it is not contended that epilepsy was uniformly transmitted. What happened was that each member of the offspring presented some morbid symptom—usually some nervous trait, such as epilepsy or paralysis. So that the result of Brown-Séquard's experiments would rather seem to be this. By producing one morbid trait in the parents, he set up a liability to one of several in the offspring. By producing a single character, he set up a tendency. All this is of extreme importance, and it may well be that the future has much that is interesting to reveal in this direction. But, meanwhile, it cannot be said to lend very much direct support to the theory now under discussion.‖

Again, the choice of lesion in these experiments was a somewhat unhappy one. Epilepsy is a symptom which can be produced in a number of ways—its prox-

* Pliny, "Hist. Nat.," lib. xxvi., cap. lxiv., ed. Franzius. Senecæ Opera, F. Haase (Lips., 1886), Epistul. Mor., lib. xv., Ep. 3 (95). Galen, "Comment. in Hipp. Aphorism," cap. xxviii., ed. Kuhn, xviii., A. 42.

* *Brit. Med. Jour.*, 1884, 707.

† See *Fortschritte der Medicin*, Bd. iii., 1885, p. 198; bacilli found in lungs of fœtal calf, æt. 8 months, whose mother was tuberculous.

‡ Ziegler and Nauwerck, "Path.," vol. i., pp. 393-94.

§ Erichsen, "Surgery," seventh edition, p. 787.

* See "St. Bartholomew's Hospital Reports," 1866.

† Observation of Mr. J. Hutchinson, quoted in Fagge's "Medicine," vol. i., p. 106.

‡ For a number of other instances, see Weismann's essay on "The Supposed Transmission of Mutilations," *passim*.

§ See Brown-Séquard, "Researches on Epilepsy," Boston, 1857; Papers in *Journal de Physiologie de l'Homme*, tom. i. and iii., 1858, 1860; *Archives de physiologie normale et pathologique*, tom. i.-iv., 1868-1872. Ziegler and Nauwerck, vol. i., p. 390. See also Weismann on Brown-Séquard, pp. 81, 310, 313; translation, edited by Poulton.

‖ For other instances of supposed transmission of morbid characters artificially produced, see Ziegler and Nauwerck, "Pathology," vol. i., pp. 391-92; Brown-Sequard's operations on eyes, Mason's on the spleen.

imate cause, if there be a single one, we are not as yet in a position to formulate. Attempts in this direction usually go no further than a vigorous and often highly poetical description, in which metaphors drawn from the phenomena of electricity are liberally employed. It might have been more advantageous to have aimed at the production of less equivocal symptoms, whose pathology is less disputed—such, for example, as facial palsy.

Lastly, we cannot exclude from these experiments the possibility of the introduction into the system of chemical poisons or even parasites, as incidental results of the operations.

But this does not by any means exhaust our stock of instances. The pages of pathology furnish us with more than one group of important facts which satisfy all the conditions of acquired characters.

Chief among these stand those numerous modifications of various organs which we regard, and rightly regard, from a clinical point of view, as part of a given disease, but which might perhaps be more correctly described as secondary adjustments made by the organism to meet certain primary morbid changes induced in different organs by the disease itself. Such, for example, is hypertrophy of the heart consequent upon valvular disease. Such hypertrophy is or is not a morbid symptom according to the point of view we happen to take. From the clinical standpoint it may be conveniently treated as part of the disease. From the biological standpoint it is an effort on the part of the organism to adjust itself to altered conditions brought about by the disease. It is certainly an acquired character, in the strict sense of the term.

An illustration will make this plain. Rheumatic fever is an hereditary disease.* Inflammation of the valves of the heart is common in rheumatic fever, and hypertrophy of that organ often follows as a consequent of this. But who would reckon hypertrophy of the heart as forming part of a rheumatic inheritance? It is true, no doubt, that whoso is heir to a disease is heir by implication to all the biological incidents of that disease. But he is not heir to them for the same reason. The one belongs to him as the inheritor of a morbid tendency, the other as the possessor of an organism. Diabetes, again, is in some cases markedly hereditary. Secondary characters are acquired in the course of this disease also; such as hypertrophy of the bladder or stomach. But, however doomed from his cradle to diabetes a person may be, he is not born with an hypertrophied bladder and stomach. We should think it absurd that such accommodations as these should be made before they were wanted. If, then, we are right in regarding these as really acquired characters—and it is difficult to see how we can avoid so doing—it seems that pathology has here afforded us a sort of crucial experiment. Of the morbid characters of which sundry diseases are constituted, some are inherited, some are acquired—the one are constantly transmitted, the others, so far as we know, never are.

But no one pretends that every disease is inherited. Consider, for example, such a disease as lead-poisoning. Here, there is not, obviously, any element of heredity. That two people are not equally liable may be true enough; that predisposing causes exist is doubtless the case; but that does not prove an element of heredity. Predispositions may be themselves acquired, as is the case in alcoholism. In such cases as lead-poisoning, we rightly stress the importance of the environment, and minimize inherited tendencies. But such diseases will be of little use to us here, unless two conditions are complied with. The first is that they leave durable and definite lesions behind them; the second is that such lesions are not inconsistent with the procreation of children. Of such lesions the familiar "wrist drop" of lead-poisoning may be cited as a good example. It is often durable; in not a few cases it is not cured; it is not inconsistent with the procreation of children. But there is no evidence to show that this or kindred lesions are ever transmitted. Facial palsy would be another instance, this malady being often of considerable duration. This group of cases constitutes another piece of negative evidence, not so important as the last, because these cases are rarer, but still not unimportant.

It can hardly be disputed that these characters are acquired in the sense under discussion. There must have been frequent opportunities of transmission, but we have no evidence of anything of the kind.

The general conclusion we have arrived at in this paper is that pathology, so far from offering any support to the hypothesis of the transmission of acquired characters, pronounces against it. We have seen that it is possible to bring up a mass of evidence, which seems at first sight to favor that hypothesis. On further consideration, however, it becomes clear that only a small portion of that evidence can be allowed to "rank."

A considerable number of facts must be rejected, because though there can be no doubt that the morbid characters here present are both acquired and transmitted, they are not acquired in the sense under discussion—that is, by the somatic cells exclusively—but by the entire organism.

A considerable number of facts, again, meet with a like rejection, because there is no question that here certain morbid characters are transmitted, yet even supposing them to have been acquired, it does not appear that precisely what was acquired is transmitted, but something broader and more general.

A considerable number of facts remain which may be allowed to "rank" as genuine instances of acquired characters. These, if the hypothesis be correct, should be transmitted. But of such transmission we find little or no trace.

If we begin with scars and mutilations, even if the facts are not all on one side, the balance of evidence is decidedly against the hypothesis. If we appeal to the results of experimental research, the question is more open; but if the hypothesis does not encounter quite so decided an opposition in this quarter, it can scarcely be said to derive much support there.

If we pass into the main region of pathology, we have to use some circumspection in looking about for instances which shall be genuine examples of acquired characters. That such instances really exist it has been our endeavor to show, notably in those secondary characters which organisms acquire by way of accommodating tnemselves to the effects produced by disease. So far from being rare or recondite, these constitute a group of familiar and well ascertained facts. If transmission has not occurred, it cannot be for want of opportunity—there must have been scores of such opportunities. That it has not occurred constitutes a piece of very important evidence against the hypothesis under discussion.

Henry J. Tylden.

* "Treatise on Medicine," by Fagge and Pye-Smith. Third edition, vol. ii., p. 694.

THE SUN A GREAT MAGNET.*

We propose to consider, this evening, the fast growing belief and evidence of the part played by those mysterious elements, magnetism and electricity, in the great problems now engaging the serious attention of scientists as to the nature and force of these elements as variable exponents in the cosmical relation of the sun and all the bodies of our solar system.

The idea of our vast solar orb being not only a great magnet with a radiant field covering the whole area of the solar system, as well as a magazine of electric energy, and perhaps without a limit in its field of force, is not a new one.

The difficulties besetting the investigation of obscure or occult phenomena and indirect effect of agents and forces that we cannot handle and harness to our will has been one of the drawbacks upon magnetic and electric investigation.

The fact of the existence of the invisible static force of gravity, and its active and equally invisible opponent generated by circular motion, lay dormant through all the ages of the old civilized world to stand forth at the dawn of enlightenment; while yet another century elapsed ere electricity and magnetism were recognized as forming an essential feature in the physics of our globe; and yet another century is nearly past ere their cosmical force is beginning to be appreciated.

Their hidden natures ever standing in the way of positive and exact investigation seem to have been a bar to progress.

Magnetism as a force has an intimate relation to electricity, as is well shown in the fact that they are netic force and heat travel through space in the same manner, but with different degrees of activity and different degrees of affinity. Their affinities become contradictory or antagonistic in a curious and most incomprehensible manner. We think we understand, or try to understand, the true nature of color, of interference in light and heat waves, of the counter induction of electric and magnetic force, and yet we must still say that they are as ever a mystery.

As gravity and centrifugal force can safely be assigned as the allotropic or static elements that control cosmic matter in motion, so light, heat, electricity and magnetism or their interchangeable combinations may be as safely assigned as the active elements of the solar system, and as far as we may know the entire universe.

No more fascinating mystery has engaged the attention of astronomers than that which the solar corona presents; that vast and somewhat irregular halo surrounding the orb of day, but never seen except when the sun is totally eclipsed, has been a centenarian theme of theorizing, but until very lately treated as a material element.

Professor Hastings cast a doubt upon that condition and expressed his belief, after an investigation of the late eclipses, that the accepted theories regarding the sun's atmosphere will have to be abandoned.

The idea that a mass of matter as an incandescent gas extending from 600,000 to 1,000,000 miles from the body of the sun, showing a radiant, ever-changing form, does not hold to reason, nor to the nature of gravitating matter under the repulsive effects of heat, as shown by the action of the eruptive prominences, which by their natural motions, so like the effects that are produced upon the earth, give fair evidence as to their nature, and a very satisfactory one as shown by the spectroscope.

The discordances and vagaries of the corona, as revealed by the spectroscope during the eclipses of the past few years, and the close relations of some of the comets in their perihelion passages, nearly grazing the sun's surface without apparent retardation or disturbance of their orbital relations, in fact, in one case, pass-

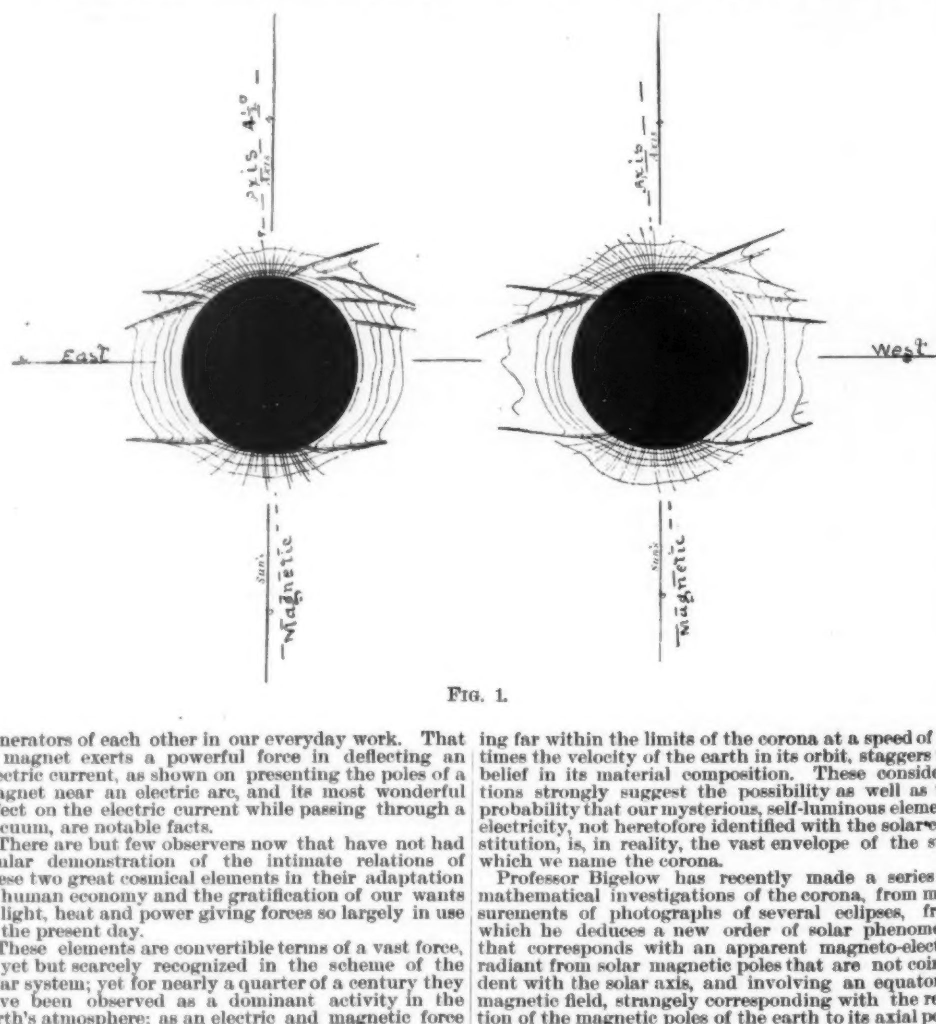


Fig. 1.

generators of each other in our everyday work. That a magnet exerts a powerful force in deflecting an electric current, as shown on presenting the poles of a magnet near an electric arc, and its most wonderful effect on the electric current while passing through a vacuum, are notable facts.

There are but few observers now that have not had ocular demonstration of the intimate relations of these two great cosmical elements in their adaptation to human economy and the gratification of our wants in light, heat and power giving forces so largely in use at the present day.

These elements are convertible terms of a vast force, as yet but scarcely recognized in the scheme of the solar system; yet for nearly a quarter of a century they have been observed as a dominant activity in the earth's atmosphere; as an electric and magnetic force coincident with observed disturbances upon the solar surface.

The numerous observations of coincident effects of disturbance on the solar surface with magnetic and auroral phenomena on the earth and in its atmosphere need not be itemized here; for they have been the subject of publication for many years; but the conclusions of investigators as to the properties and periodicities of these mysterious elements claim serious attention.

More than twenty years ago Clerk Maxwell asserted that light was an electro-magnetic wave movement.

Following this suggestion, Professor Hertz, of Brown University, in a series of well defined experiments, has shown that electro-dynamic force is, like light, a wave motion propagated through interplanetary space, the luminous ether, the atmosphere, and through fluids and solids that are akin to its power of transmission, and, like light, is subject to reflection, refraction and concentration by means of lenses. He assigns a longer wave length than that due to light, but claims a velocity of transmission equal to that of light.

From this we are led to infer that light, electro-mag-

ing far within the limits of the corona at a speed of 180 times the velocity of the earth in its orbit, staggers the belief in its material composition. These considerations strongly suggest the possibility as well as the probability that our mysterious, self-luminous element, electricity, not heretofore identified with the solar constitution, is, in reality, the vast envelope of the sun, which we name the corona.

Professor Bigelow has recently made a series of mathematical investigations of the corona, from measurements of photographs of several eclipses, from which he deduces a new order of solar phenomena that corresponds with an apparent magneto-electric radiant from solar magnetic poles that are not coincident with the solar axis, and involving an equatorial magnetic field, strangely corresponding with the relation of the magnetic poles of the earth to its axial pole. He holds that the corona is an electro-magnetic phenomenon.

It has long been known that auroras and magnetic storms increase and diminish in like ratio with each other, and strongly suspected to have a close relation to the outburst of spots on the solar surface; yet from want of exact coincidence at all times, an anomaly has been met that required something to reconcile the irregularity of the observed phenomena.

It required only a later and sharper observation to show that something else upon the sun besides the dark spots is concerned in the production of magnetic phenomena or magnetic storms, which often occur in the absence of such spots, at least on the visible surface.

The solar surface is observed to be covered with a layer of great brightness that is in constant agitation—the "willow leaves" of the older astronomers, now designated as the feculæ of the photosphere. There is a constant movement of the feculæ like the waves of the sea, largely increased in the neighborhood of sun spots, and even during the minimum sun spot period show an unequal activity on different parts of the solar surface.

Carrington's famous observation in 1859 of a disturbance on the surface of the sun, coincident with a mag-

* G. D. Hiscox in a lecture before the Astronomical Department of the Brooklyn Institute of Arts and Sciences, Dec. 14, 1891.

netic storm and aurora, was not in connection with sun spots, but was entirely fecular.

Another and similar instance, described by Professor Young, was followed by a sun spot.

There is a singular periodicity of magnetic and auroral display that has been observed at times corresponding with the rotation of the sun. This has been observed for periods of four and five successive rotations. Its continuance has not, as yet, been fully established.

Isolated magnetic storms may occur at any time, and are, when taken individually, beyond the power of prediction.

Their presence is generally indicated by sudden deflections, and by rapid and great fluctuations in the direction of the magnetic needle from its normal direction.

They often take place simultaneously over distant regions of the globe, and in duration may be confined to a few hours, a day, or for several days. Its intensity generates earth currents and sometimes induces strong electric currents in our telegraph and telephone systems.

At night the aurora becomes a vivid index and simultaneous reminder of what is manifested in the motions of the magnetic needle. These motions in mid-latitudes are found to vibrate from 1 to 2 degrees and in polar regions from 4 to 5 degrees.

Sun spot activity in relation to rainfall has been a subject of observation and discussion for the past quarter century. Professor Reis has made an exhaustive study of this phenomenon in relation to high water and excess of rain in the watershed of the river Rhine, and finds an agreement between the maxima of sun spots and flood seasons for several hundred years.

He also finds a cycle of 110 years, or about ten times the Wolf sun spot period, and twice Fritz's 55-year period, and a "secular period" of 222 years. These are periods in the variations of the mean of the 11-year periods.

From a most exhaustive investigation of the relation of sun spot activity to meteorology during the greater part of the present century in New South Wales, a district well suited for comparison, isolated as it is among the vast waters of the southern ocean, where the influences of other continental areas are too distant to effect a result due to solar influence, it has been found that the curves of magnetic and electric phenomena on the earth follow very closely the changes in solar activity, and that the influence does not stop here, but is extended to a well-defined and corresponding cycle in the rainfall.

With these points in view, who can say that the sun and earth have no stronger ties of relationship than gravity, light and heat, in the face of evidence of the wonderful electric and magnetic manifestations constantly and simultaneously exhibited over so vast a distance?

From the dozen lantern slides illustrating the theme of the lecture we reproduce illustrations of its leading features.

In Fig. 1.—At the moment of totality in the eclipse of 1878 photographs were taken at Cresson and Junta stations, showing the characteristics of the corona, from which Prof. Bigelow has deduced the magnetic field, as shown in the cut, and from which he has deduced the magnetic axis of the sun to be 4⅓° from the axis of revolution, and the zone of magnetic polar force or radiant as extending from 29° to 39° from the magnetic polar axis, while the whole contour of the coronal lines has a strong resemblance to the well-known lines of force in a spherical magnet.

Prof. Bigelow has also, through a series of computations, deduced the periods of the sun's zonal rotation as a fluid body, making the polar rotation 27¼ days, the equatorial rotation 25 days, and has tabulated the rotation of each 10° zone from the poles to the equator; his figures differing but slightly from the previous figures of Spoerer, Tisserand and Faye.

In Fig. 2 is illustrated the position of the terrestrial magnetic axis to the direction of the solar magneto-electric rays for a diurnal revolution. It will be readily seen that with an inclination of the axis of revolution of 23½° to the ecliptic, and the magnetic axis at 29° from the terestrial axis, the total variation of the magnetic axis to the direction of the solar magnetic rays is 58° on the 21st of June, for each diurnal revolution, 52½° representing the noonday dip of the north magnetic pole to the sun. The change in the amount of dip then decreases during the season until the 21st of September, when its dip is but 29°, the total variation being still 58°, but divided by its inclination, being to and from the solar radiant during each diurnal revolution. During the remainder of the year the north magnetic pole has a mean traverse away from the solar influence until on December 21st the opposite from the June position has arrived, and the southern magnetic pole becomes intensified, while the north pole has but a noon inclination of 5½° toward the sun, and a midnight inclination of 52½° from the vertical to the plane of the magneto-electric radiant.

Thus the varying position of the magnetic axis of the earth with the direction of the solar magnetic radiant produces an observed diurnal variation of the declination and intensity of the magnetic needle, and also a seasonal variation and intensity quite notable. The ellipse in Fig. 2 shows the swing of a free needle during a diurnal revolution of the earth. Its greatest movement in northern mid-latitudes, say at Philadelphia, reaches 10¼ minutes of amplitude in summer, decreasing to six minutes in winter, showing that the impact of the solar magnetic radiant is greatest when the terrestrial magnetic pole is most inclined toward the sun for each hemisphere, north or south.

There has also been found a small deviation of the needle of a few seconds only, corresponding with the sun's rotation period of 27 days, which may probably be found to be due to the inclination of the magnetic axis of the sun.

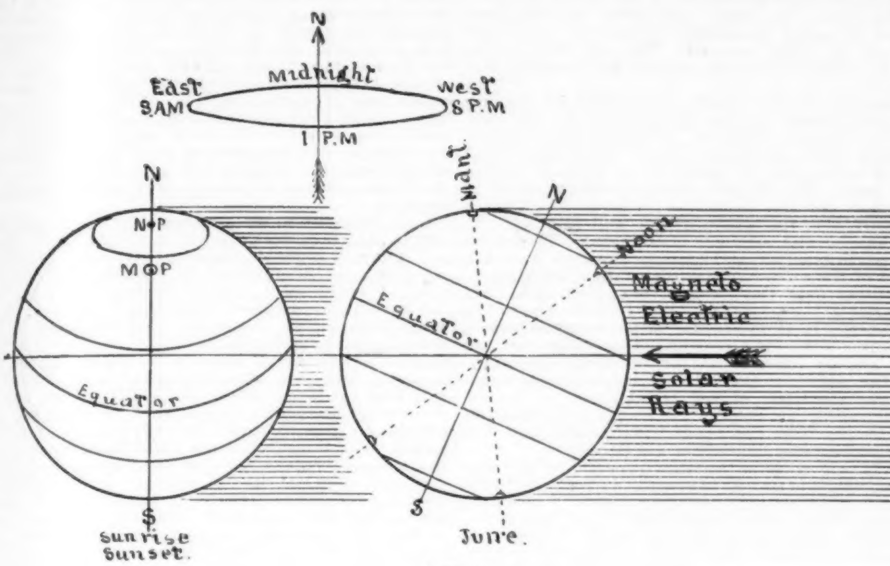


FIG. 2.

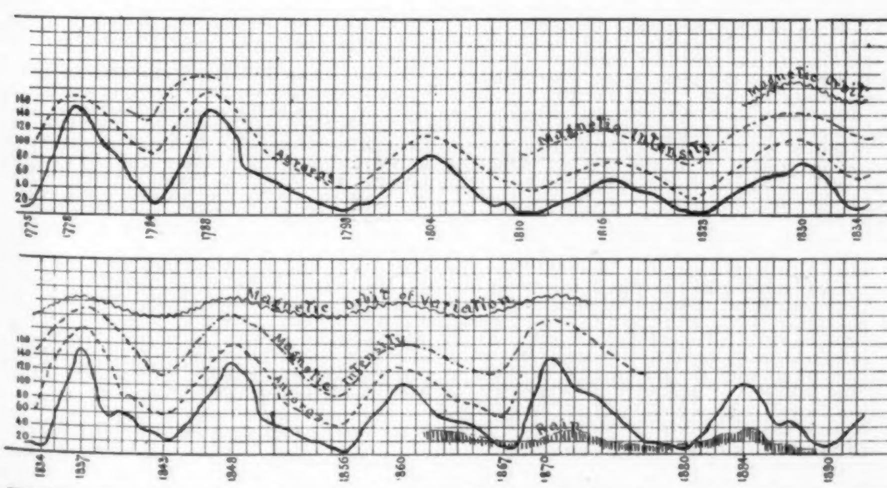


FIG. 3.

The moon shows evidence of magnetism and magnetic influence by a variation of the needle amounting to nearly half a degree between the extreme lateral position at the first and last quarter.

The range of the magnetic needle also varies with the sun spot intensity and amounts to, according to the Paris observations, 12 to 15 minutes, and during magnetic storms or auroras to one or two degrees.

The correspondence of solar activity with the magnetic orbit of variation and intensity, auroras and rainfall, is graphically illustrated in Fig. 3, where the observed phenomena of the past hundred years are delineated for ocular comparison. The continuous black line indicates the range of sun spots by relative numbers as figured at the left hand side, with the years of maxima and minima figured beneath. The dotted lines show the magnetic and electric manifestations upon the earth corresponding with observed solar activity, decidedly periodic in time, and of uniform cause, as indicated by the similarity of curves under the cyclular variations of five, ten and twenty periods as before mentioned. The variation in rainfall as observed in New South Wales during the past 30 years is indicated at the right of the lower section, Fig. 3, which is confirmed in its following of sun spot activity, as length of time gives opportunity for comparing a greater number of periodic intervals.

In conclusion, there can be no doubt but that the sun harbors a vast and most active electric and magnetic force, which in its own peculiar way covers the whole solar system with its benign influence and in which the planets are whirling as in the field of a great magnet.

THE SURFACE FILM OF WATER, AND ITS RELATION TO THE LIFE OF PLANTS AND ANIMALS.*

By Professor L. C. MIALL, F.L.S., Professor of Biology at the Yorkshire College, Leeds.

THERE are many plants which take advantage of the property of the surface film of water, which prevents it penetrating small spaces, in order to keep themselves dry. You must have observed how the hairy grasses repel water. The surface film is unable to pass into the fine space between the hairs, and accordingly the water above the surface film is kept from contact with the leaf. This simple artifice is often employed by plants which float at the surface of water. Here it is important that they should keep dry, not only for the purpose of respiration, but for another reason too. They commonly have great power of righting themselves when accidentally submerged, and this self-righting property depends upon the fact that the under surface of each leaf is always wet, while the upper surface is incapable of being wetted. The microscopic hairs which thickly cover the upper surface are sufficient to exclude the water. A leaf of pistia being submerged, you may see by the gleaming of its surface that it is overspread by a continuous flat bubble of air, which looks like quicksilver beneath the water. On inverting a leaf of pistia by means of a rotating lever it is brought up beneath the surface of the water in an inverted position, and it is seen that, notwithstanding its buoyancy, it is unable to free itself and rise to the surface, because of the air bubble, which adheres both to the leaf and to the disk at the end of the lever, and ties both together. Complete separation of the leaf from the disk would involve the division of the air bubble into two smaller bubbles, one adhering to the leaf and the other to the disk. In this operation the surface film would necessarily be extended directly in opposition to its natural tendency to contract. Several other water plants exhibit the same properties as pistia. I will mention two of the water ferns—salvinia and azolla. Salvinia is found floating on still water in the warmer parts of Europe, as well as in other quarters of the globe. The leaves are attached on opposite sides of a horizontal stem. Long hairy roots (or what look like roots, and really answer the same purpose) hang down into the water. Salvinia has in a remarkable degree the power of rising when submerged, of always rising with its leaves up and its roots down, and of rising with the upper surface of its leaves perfectly dry. It is obvious that these qualities are most useful to a plant which may be pressed under water or drenched with rain. Its nutrition, like that of all green plants, depends largely upon substances extracted from the air; and to be overspread with water, which disappeared only by a slow process of evaporation, would be disadvantageous, especially if the water were not absolutely clean. Every leaf of salvinia is, to begin with, excavated by a double layer of air spaces, which lodge so much air as to give it great buoyancy. On the upper surface are placed at regular distances a number of prominences, each surmounted by a group of about four stiff spreading hairs, which keep the water from reaching the surface of the leaf. When forcibly depressed, the salvinia takes down with it a layer of air, which forms a flat bubble over the leaf, and of course gives great power of self-righting, for the specific gravity of the upper side is greatly reduced, while the lower side is weighted, as before, by the long, water-logged roots. Once restored to the surface, the bubble bursts, and the little drops into which it is instantly resolved roll off like drops of quicksilver. Azolla, which is found in most hot countries, and is often grown in hothouses, behaves in a very similar way. Here the leaves are far smaller, and crowded together upon a branching stem of minute size. There are a few hairs upon the upper surface, and between the leaves are narrow clefts, connected with globular cavities, which occupy the center of every leaf. These cavities, which are often closed, and never possess more than an outlet of extreme minuteness, are always filled with air; so are the clefts between the leaves. No water can lodge on the upper surface, apparently because the surface film is stretched from the raised edge of one leaf to that of the next; and thus buoyancy, self-righting, and repulsion of water are efficiently secured.

Many plants which ordinarily float on the surface of the water (salvinia, azolla, duckweed, *Potamogeton natans*, etc.) sink on the approach of winter. At this

* A lecture recently delivered at the Royal Institution.

time it is very curious to see how completely they lose both their buoyancy and their power of repelling water. I do not know how this change is brought about, but the result is one of obvious advantage. The leaves, or in some cases the entire plants, sink to the bottom, and hibernate there, out of the reach of frost. Many perish; some are broken up by decay into isolated buds. When spring returns, the few survivors float up, and soon cover the surface with leaves. It would be interesting to know something of the mechanism by which these seasonal changes are effected.

One of the commonest objects in nature, which is apt to escape our notice on account of its minute size, for it is less than one-quarter of an inch in length, is the egg raft of the gnat. This was beautifully described 150 years ago by Reaumur. The eggs of the gnat are cigar shaped, and 250 or 300 of them are glued together, so as to make a little concave float, shaped like a shallow boat. The upper end of each egg is pointed; the lower end is provided with a lid, through which the larva will ultimately issue into the water. The gnat in all stages, even while still in the egg, requires an ample supply of air. It is therefore necessary that the egg raft should float at the surface; it is also necessary that it should always float in the same position, so as to facilitate the escape of the larva. This is effectually secured by a provision of almost amusing simplicity. Let us first notice how efficient it is. If we take two or three of these tiny egg rafts, and place them in a jug of water, we may pour the water into a basin again and again. Every time the egg rafts float instantly to the surface, and the moment they come to the top, they are seen to be as dry as at first. The fact is that the surface film cannot penetrate the fine spaces between the pointed ends of the eggs. The cavity of the egg raft is thus overspread by an air bubble, which breaks the instant it comes to the top. The larva of the gnat, when it escapes from the egg, floats at the surface, and it is enabled to do so in consequence of the properties of the surface film. When the larva changes to a pupa, it becomes buoyant, and floats at the surface, except when alarmed. To enable it to free itself without unnecessary effort from the surface of the water, the respiratory tubes of the pupa are furnished with a valvular apparatus, which can cut the connection with the air in a moment, and restore it at pleasure, when the pupa again floats to the surface.

Another dipterous insect whose larva inhabits rapid streams, makes an ingenious use of the properties of the surface film. This is the larva of simulium, of which I have given some account in a previous lecture. At the time of the delivery of that lecture, I was wholly unable to explain how one difficulty in the life of the insect is surmounted. The larva clings to the water weeds found in brisk and lively streams. The pupal stage is passed in the same situation. But a time comes when the fly has to emerge. Now the fly is a delicate and minute insect, with gauzy wings. How does it escape from the rushing water into the air above, where the remainder of its life has to be passed? This was a question upon which I had spent much thought, but in vain. It appeared to me for many months completely insoluble. However, I was informed last year by Baron Osten Sacken of a paper written by Verdat, seventy years ago, in which the emergence of the fly of simulium is described. Guided by Verdat's description, I had little difficulty in seeing for myself how the difficulty is actually overcome. During the latter part of the pupal stage the pupa case becomes inflated with air, which is extracted from the water, and passed through the spiracles of the fly into the space immediately within the pupal skin. The pupal skin thus becomes distended with air, and assumes a more rounded shape in consequence. At length it splits along the back, in the way usual among insects, and there emerges a small bubble of air, which rises quickly to the surface of the water and there bursts. When the bubble bursts out comes the fly. It spreads its hairy legs and runs upon the surface of the water to find some solid support up which it can climb. As soon as its wings are dry it flies to the trees or bushes overhanging the stream.

A very interesting inhabitant of the waters, which makes use of the properties of the surface film to construct for itself a home beneath the surface, is the water spider (*Argyroneta aquatica*). This interesting little animal has been described by many naturalists, some of whom, judging from their accounts, had no personal acquaintance with its habits. But among the number is the eminent naturalist Felix Plateau, son of the physicist to whom we are so much indebted for our knowledge of the phenomena of surface tension. I need hardly say that in his account of the water spider, Professor Plateau gives a full and adequate account of the scientific principles concerned in the formation of its crystalline home. Plateau remarks that the water spider, like all other spiders, is an air-breathing animal. It dives below the surface, and spends nearly its whole life submerged. In order to do this without interruption to its breathing, the spider carries down a bubble of air, which overspreads the whole abdomen as well as the underside of the thorax. These parts of the body are covered with branched hairs, so fine and close that the surface film of water cannot pass between them. The spider swims on its back and the air lodges in the neighborhood of the respiratory openings, which are placed on that surface which floats uppermost. When the spider comes to the top, as it does from time to time to renew its supply of air, it pushes the abdomen out of the water, and we can then see that this part of the body is completely dry. When it sinks, the water closes in again at a little distance from the body, and the bubble forms once more.

It would be inconvenient to the water spider to be obliged to come frequently to the surface for the purpose of breathing. A predatory animal on the watch for its victims must lie in ambush close to the spot where they are expected to appear, and the water spider accordingly requires a lurking place filled with air beneath the surface of the water. It has its way of supplying this want. Relying on the fact, already illustrated by our muslin bag, that the surface film of water will not readily pass through small openings, the spider proceeds as follows: It begins by drawing together some water weeds with a few threads, in such a way that they meet at one or more points. It then fetches from the surface a fresh supply of air, and squeezes part of it out by pressing together the bases of its last pair of legs. The bubble rises, but is detained by some of the threads previously spun across its path. Then the spider returns to the surface to fetch another bubble, and repeats the operation as often as is necessary. Now and then she secures the growing bubble by additional threads, and before long has a bubble nearly as big as a walnut, inclosed within an invisible silken net, which imprisons the air as effectually as a dome of glass would do. The spider takes care to conceal her home from observation, and before long the minute algæ, growing all the more vigorously because of the air brought to them, effectually conceal the habitation. The mouth of the dome, which is of course beneath, is narrowed to a small circle, and Plateau has observed a cylindrical horizontal tube, seven to eight millimeters in diameter, by which the spider is enabled to enter or leave her home without being observed. The air within is renewed as required, by the visits of the spider to the surface.

Besides this home, which is the ordinary lurking place of the spider, another is required at the time when the young are hatched. The new-born spiders are devoid of the velvety covering of hairs, and would drown in a moment if placed in a nursery with a watery floor. The female spider therefore makes a special nest for this particular occasion, which floats on the surface of the water, rising well above it. It is bell shaped and strongly constructed. The upper part is partitioned off, and contains the eggs. Beneath the floor of the nursery the mother takes her station, and watches over the safety of her brood, defending them against the predatory insects which abound in fresh waters. It is interesting to see how the faculty of spinning silk, used by the house spider for her snares, and at other times for the fluffy cocoon in which the eggs are enveloped, furnishes to the water spider the materials of her architecture. It is not less interesting to observe the economy of material which results from the use of the tenacious and contractile surface film, in place of a solid wall.

We will next consider another property of the surface film, which is turned to account in the daily life of the very commonest of our floating plants. I mean the duckweed, which overspreads every pond and ditch. If a number of the green floating leaves of duckweed are placed in a shallow dish, they will be seen to have spontaneously arranged themselves in a very irregular fashion, forming strings and chains which spread hither and thither over the surface of the water. This is not the way in which most floating bodies behave. Removing the duckweed and replacing it by another dish of water in which is put a number of small disks of cork, you will see that the bits of cork are attracted one to another and crowd together in one place. Let us inquire why the floating bits of cork are thus attracted toward one another. If any solid capable of being wetted by water is partially immersed in water, the liquid rises round it in an ascending capillary curve. If the solid is not wetted by water, the curve will turn downward. We may get ascending or descending capillary curves in other ways. If, for instance, I were to lay a sheet of paper upon water, and turn its edges up at certain places, we should get marked ascending curves at these points. The raising of some parts of the surface causes other parts to sink, and may bring about descending curves, or make previously formed descending curves more marked. We shall find it helpful in our experiments to notice one very simple plan of producing a descending capillary curve round the edge of a vessel. If we take a glass of water, and fill it until the water is level with the brim, we naturally speak of the glass as *full*; but if we are careful to avoid rude shaking, we may still add a considerable quantity of water without spilling any. The glass will then become what we may term *overfull*, and its surface will be bounded by a descending capillary curve. Now, it is of immediate importance to us to observe that *like* capillary curves, whether ascending or descending, attract one another, and that *unlike* curves repel one another. The theoretical explanation of this point is not difficult, but it must not detain us here. To place the fact itself beyond dispute, we may try a little experiment. If a circular dish of water be taken, and we introduce into it a small disk of wood, both the disk and the side of the vessel are wetted by water, and an ascending capillary curve rises round each. The result is that the two bodies attract one another. Every time the disk is moved away it is powerfully drawn toward the side of the vessel. On adding water to the dish in sufficient quantity to raise the level above the edge of the vessel with a little syringe, it is observed that the wooden disk is repelled by the edge of the vessel, and floats free in the center. By sucking up a little water it becomes attracted once more, and so we may go on, causing it to be attracted or repelled, according as we add or subtract a small quantity of water. But what has all this to do with the duckweed? In order to explain the behavior of duckweed, it is necessary to examine a careful representation of its form. This common plant has not, to my knowledge, been faithfully represented in any botanical book. The leaf is of an irregular oval shape, broader at one end than at the other, and the narrow end is pointed. A raised ridge extends along the length of the leaf, from the point to the middle of the opposite or rounded border. Duckweed almost invariably propagates itself by budding. New leaves are pushed out symmetrically on each side of the point. They grow bigger and bigger, and gradually free themselves. The point upon each leaf marks the place where it was last attached to the parent leaf.

Sometimes the budding is so rapid that before a fresh pair of leaves have become free they have already budded out a second pair, which we may call the granddaughters of the parent leaf. The pointed end of the leaf and also the opposite end of the ridge are raised above the general level, and very marked capillary curves ascend from the general water level to these points. The free edge of every bud is also raised above the general water level, and a capillary curve ascends to meet it. Hence, when a number of leaves of duckweed are floating freely on water they are powerfully attracted one to another at certain points, while at intervening points they are relatively inert. If you take a floating leaf of duckweed and bring near it a clean needle or a pencil point, or any similar object, provided that it is not greasy, you will see that the leaf is at once attracted toward the point, but it always turns itself so as to bring one of its ascending curves round to the needle or pencil.

We can all see how readily a leaf of duckweed is made to rotate rapidly by causing a needle point to revolve round it without ever touching it. To imitate the behavior of the leaves by some rude models, some elliptical paper floats, cut out with a pair of scissors, and having each of the pointed ends a little turned up, may be placed one by one on the surface of the water, and will be seen in the lantern to be attracted to one another, point to point, and forming long chains, which have a tendency to break up into stars. It is the existence of such points of attraction on the margin of the leaves which causes the duckweed to form chains and strings, so long as there is any unoccupied surface in the pond. A moment's consideration shows how profitable this tendency is to the plant. Were the duckweed to crowd together like the floating bits of cork, the pressure toward the center of any considerable mass of plants would be so great that the new leaves budded out would find no room in which to expand; but, by virtue of one very simple provision, viz., the existence of inequalities of level among the edges of the leaves, clear spaces and lanes are left between the floating leaves, so long as any unoccupied space remains.

Long exposure to the air, especially in still weather, affects the life of duckweed in a material way. Dust and decaying organic substances give rise to a pellicle, which is most mischievous to floating plants; and I think I could show, if time allowed, how much the habits of duckweed have been altered thereby. But, apart from visible impurities, mere exposure to air gives, as Lord Rayleigh has taught us, a considerable degree of superficial viscosity to water. Hence, the leaves of duckweed, when the surface is contaminated, will tend to lie in whatever positions they may be thrown by accidental causes, such as wind, and the attractions due to capillarity will be more or less impeded. But the effect of the superficial viscosity will in time be overcome by the attractive forces, so that it probably does not in the long run greatly affect the distribution of the leaves over the surface of water. Many other floating plants, but not all, behave more or less like duckweed, and for the same reason. As yet I know of none which space themselves quite so effectually, and the extreme abundance of the common duckweed, as well as its world-wide distribution, may be partly due to the completeness of its adaptation to capillary forces.

Some dead objects may accidentally take a shape which causes them to spread out over water, but I have met with none which have particularly struck me.

Floating natural objects, such as sticks or seeds, behave, in many cases at least, very differently, and become densely massed. My attention was first called to this subject by seeing how different was the grouping of duckweed from that of some seeds of *Potamogeton natans*, which were floating in the same pond. The capillary forces which spread the leaves of duckweed or azolla upon the surface of the water are indirectly concerned in the transport of these and like plants to fresh sites.

If we put a stick into water overspread with duckweed, we cannot fail to notice how the leaves cling to the stick. They cling in a particular way, which enables them to bear transport more safely. The wetted surface, for obvious physical reasons, is attracted to the wetted stick; and the water-repellent surface, which is that which best resists drying, is outward. The tenacity with which duckweed clings to the legs of the water birds, and the position which it almost inevitably takes under such circumstances, may have a good deal to do with the safe transport of the plant to distant pools.

It is not, I think, too much to say that the prosperity of duckweed depends very largely upon the capillary forces which come into play at the surface of water.

We have now exhausted our time, though I have been obliged to leave unnoted many special adaptations of living things to the peculiar conditions which obtain on the surface of the water. Had time allowed, I should have been glad to say something about the aquatic animals which creep on the surface film as on a ceiling, and about the insects which run and even leap upon the surface film without wetting their minute and hairy bodies.

All small animals and plants which float on water necessarily come into contact with the surface film and have to deal with the difficulties which result from it. We have seen that they generally manage in the long run to convert these natural difficulties into positive advantages. I have to thank my colleague, Dr. Stroud, for his frequent explanations of the physical principles upon which these adaptations depend, and also for much practical and valuable help in the preparation of suitable experiments.

THE LANGUAGE OF MONKEYS.

A LADY correspondent of the *Spectator* writes as follows: "Some attention has been aroused by the recent attempt to reproduce monkey talk by means of the phonograph. It is perhaps not generally known that in a little book, published nearly a hundred years ago, at the sign (strangely enough) of the Tour de Babel, on the Quai Voltaire, Paris, a French writer made an endeavor to reduce the chatter of the tiny marmoset to articulate translatable language. The whistle, or *ouistiti*, from which this little creature has its French name, he describes truly as a long, sharp, piercing sound, repeated two or three times, signifying the want of something or some one. I would add to this, that it is evidently the call used by one to the other. A very young one that I had always cried 'Ouistititi, ouistitititi,' to the older one for help, if it thought itself in danger. 'Ghriii,' a long-drawn high tone, he translates into 'come.' All those that I have possessed have thus called me to come to them. 'Guenakiki' expresses, he says, terrible fear; 'Trouakki,' violent, despairing grief; 'Trouagno,' intense pain, 'save me.' One that had broken its leg thus warned me of it. 'Krrrreoeoeo,' often repeated, means very happy indeed; 'Keh,' a little better; 'Korrie,' an-

noyed, disturbed; 'Ococo,' deep terror; 'Anic,' feebly and melodiously uttered, means help! protect! 'Quih,' 'I want something very much;' 'Quoueee,' despair of escaping some danger—this sound I have often heard all my marmosets make at the sight of anything strange to them, or which reminded them of some known danger."

THE TURTLE INDUSTRY.

Of the many who enjoy those delicacies, turtle soup and turtle steak, few here at the North know where the supply of these clumsy marine reptiles are captured or anything about their habits. The turtle is essentially a warm water reptile, and is rarely found north of Moorehead City, N. C. To find him in perfection one must go to the tropical waters of Florida. This State supplies two-thirds of the American catch, and half of all the turtles caught on the Florida coast are shipped to New York by steamer.

There are five species of turtle that inhabit the warm waters adjacent to the coast of Florida. Of these the green turtle is the most highly prized for the superior quality of its meat.

This is of a straight grain and tender, light in color, and of a peculiarly delicious flavor. In the Key West markets it brings a higher price than any other turtle meat. The green turtle derives its name from its color. Its head is remarkably small, and, unlike any other turtle, its jaws are of a size and shape that permit the upper one to fit into the lower. The shell of the green turtle is about the thickness of stiff paper and is of no value. The general average weight is from 400 to 500 pounds. Sometimes on the fishing grounds off Cedar Keys monsters of 1,000 pounds weight are caught. The largest ever landed at Cedar Keys weighed 1,200 pounds.

The green turtle inhabits grassy bottoms and subsists entirely on turtle grass. It is obliged to come to the surface every hour to breathe or "blow."

The hawk's-bill turtle derives its name from the shape of its bill, which resembles that of a hawk. This variety gives to the world the material out of which are made the beautiful tortoise shell combs and other ornaments so dear to the feminine heart. The shell, which brings from \$4 to \$6 per pound, according to its quality and demand for it, completely covers the turtle's back, and is invariably arranged in thirteen rows. This remarkable uniformity in the number of rows regardless of the turtle's age is observed in all varieties of the reptile.

The hawk's-bill does not attain the size of other species, rarely exceeding 250 pounds in weight. Its meat is palatable and wholesome, but of a darker color than that of the other varieties. It is usually found on rocky bottoms and subsists on sponge and grass. The hawk's-bill remains under water longer than any other turtle; it comes to the surface to "blow" only once in six hours, either the last of the flood or the beginning of the ebb.

The loggerhead ranks next to the hawk's-bill in point of value. It attains about the same size, although specimens weighing 300 pounds have been caught. Its meat is of about the same quality, but its shell drops in value to 12 or 15 cents a pound. The shell is used for making cheap combs and buttons. This species of turtle inhabits rocky bottoms and subsists on sponge, grass and conch shells. Its jaws and teeth are of such remarkable strength that it is enabled to and does indulge in the delightful delicacy of the hardest and strongest conch shells. The loggerhead is frequently seen on the surface of the water, when it comes up to blow, which it does every half hour, holding in its jaws a conch weighing five or six pounds.

The bastard turtle is the offspring of the green and loggerhead turtles. It is the smallest of all, rarely attaining a weight of over 100 or 150 pounds. The flesh is edible, but not so highly prized for food as the other varieties already mentioned.

The trunk-back turtle is the largest of all, frequently reaching a weight of 1,500 pounds.

METHOD OF CAPTURE.

There are four methods employed on the American coast for the capture of turtles. In the waters of North Carolina they are caught by diving in the following manner: The turtle fisherman ties the painter of his boat to his leg and rows leisurely along until one is seen. He approaches it and dives upon it from the boat and, seizing the anterior edge of the carapace with one hand and the posterior edge with the other, he turns the head of the turtle upward, when the reptile immediately rises to the surface, bringing the fisherman with it. If the water is deep, the fisherman steers the turtle toward a shoaler spot, keeping hold of it with one hand and with the other pulling the boat after him. When a suitable place is reached, he hoists the turtle into the boat.

Another method is to strike the turtle with a spear, or "gauge," having a long line attached, but this method has been very generally abandoned, as it often injures the turtle to such an extent as to decrease its market value.

In the breeding season the female turtle crawls upon the beach, selects a warm sandy spot, digs a hole with her flippers and deposits her eggs to be hatched by the warmth of the sun. Sometimes before reaching the water she is caught, turned over on her back, thus rendering her completely helpless, and dispatched at leisure. It is no unusual thing for a turtle to lay as many as one hundred and twenty-five eggs, although from sixty to one hundred eggs is a more usual "lay."

The method usually adopted for catching turtles is by the "gill net." The size of mesh employed is about 11 inches. The nets are from 50 to 100 fathoms long, and extend from the surface of the water to the bottom. A turtle while swimming around in the water comes in contact with a net and thrusts its head through one of the meshes. Not noticing the obstruction, it attempts to continue its course, and in a short time one flipper and then the other is entangled, and the reptile is unable to extricate itself. If a fisherman is near his net, he knows by the movement of the corks on the surface that the turtle is caught, and he hastens to row up and secure it.

Turtles are kept alive in a pen or "crawl" and fed on fish and turtle grass until ready for shipment by steamer to New York. The "crawl" is an inclosure about 50 feet long by 25 feet wide, surrounded by piles driven closely together and covered above with boards. It is usually constructed near the shore in water 5 or 6 feet deep. A crane or derrick is used for hoisting the turtles.

FISHING GROUNDS.

The best turtle fishing grounds are at the mouth of the Indian River, in the channels between the keys and reefs near Key West, and along the Florida coast from thirty miles north of Cedar Keys as far south as Anclote Keys. Offshore fishing for turtles is prosecuted as far as thirty or fifty miles from shore in small vessels of from ten to thirty tons. The crew numbers three or five men, and the trip lasts eight or ten days. The nets for offshore fishing are made of the largest and strongest cotton twine, and have a length of from seventy-five to one hundred fathoms and a depth of from ten to sixteen feet. The meshes are two feet square. When the turtle grounds are reached, the vessel is kept beating back and forth until signs of turtle are noticed and several are seen to blow in one place. One of the men in a small boat makes an investigation of the depth of water in the vicinity to find the deepest spots. To these spots the turtles retire at low tide to feed. Near these spots and parallel with the course of the tide the nets are set. The turtles come to the surface to "blow," and while rising or sinking near the net are very apt to become entangled in it.—*Com. Bulletin.*

AKER TUBA (DERRIS ELLIPTICA), THE MALAYAN FISH POISON.

By Leonard Wray, Jr., State Geologist and Curator of the Perak Government Museum, Corresponding Member of the Pharmaceutical Society of Great Britain.

The fish poison known by the Malayan name of *Aker tuba* is the root of a papilionaceous woody climber called *Derris elliptica*, Benth. This plant bears bunches of pretty, fragrant, white flowers, tinted with pink and pale buff, which are followed by thin, flat, blunt-ended pods, 2½ in. long by 1 in. broad, containing one or two seeds. The leaves are pinnate, with seven to thirteen leaflets, and are whitish beneath. It flowers in Perak in February and March, and the fruit ripens in May or June.

The following is the botanical description taken from the "Forest Flora of British Burma," by S. Kurz:

"*Derris elliptica*, Benth.—A large scandent shrub, the younger parts all rusty pubescent; leaves ½–1 foot long, unpaired-pinnate, while young pubescent; leaflets in four to five pairs with an odd one, on a pubescent petiolule 2 lin. long, oblong to obovate-lanceolate, shortly and rather abruptly acuminate, 3 to 6 in. long, chartaceous, entire, glabrous above, more or less glabrescent beneath; flowers rather large, pinkish, on 2–3 lin. long, rusty villous at apex, bracteoled pedicels, peduncled-cymulose and forming an elongate, rusty, pubescent, narrow panicle in the axils of the leaves or above the scars of the fallen ones; corolla ⅔ in. long, appressed tawny silk-hairy; ovary tawny villous; pods elliptic, compressed, rather acute, about 2 in. long by 1 broad, 1–2 seeded, puberulous and glabrescent, narrowly winged along the vexillar suture. Habitat Tenasserim; flowers March; fruits August."

Loureiro's genus *Derris* includes several other poisonous plants, of which *D. uliginosa*, Benth., and *D. Forsteniana*, Bl.,* are also used as fish poisons in Malaya. Other nearly allied genera of the papilionaceous leguminosæ contain species employed for the same purpose, of which *Pongamia*, *Millettia* and *Tephrosia* may be mentioned.

Aker tuba grows apparently wild on the plains in Perak and is also rather extensively cultivated. The roots, done up into bundles, are to be bought in many of the shops, and in Thaipeng, the chief town of Perak, it sells for about 35 cts. per kati, or 9½d. per pound.

The root, which is the most virulent part of the plant, exudes, when cut, a milky sap, which under the microscope is seen to be an emulsion. The roots have a rather pleasant aromatic resinous smell, bearing a slight resemblance to that of licorice root.

It is used largely by the Chinese market gardeners as an insecticide, for which purpose the fresh roots are chopped up fine and then pounded and mixed with water, which becomes milky, and is sprayed or brushed over the plants with a bunch of feathers.

The main use of the plant was, however, until the much needed prohibition came into force, as a fish poison, for which purpose it is pounded or ground fine and mixed with stiff clay and crushed refuse, shrimps or small fish, and the mixture is then made into balls and dried. These balls are thrown into the sea, like ground bait, and fish eating them become poisoned, rise to the surface, and are caught by the watching fishermen. This way of using it is probably not very harmful, though the same cannot be said of its use in fresh waters.

By the Malays it is used in the rivers in the following way: One or more dug-out canoes, according to the size of the stream to be operated on, are partly filled with water and the pounded roots. The men then upset the boat or boats into the river, and allow them to drift down with the current, while with nets and spears they secure the fish as they rise stupefied to the surface. It is a most destructive method of fishing, killing, as it does, all the fish, little and big, for some miles along a water-way. The young fish succumb much more readily to the poison than the larger ones. In ponds and pools the destruction of the fish is even more complete than in a river, and the Malays say it is years before they become tenanted with fish again. In all instances, besides the actual effects of the poison, the fouling of the water by the decomposition of the bodies of the fish and animals of all sorts has to be taken into consideration.

By experiment I have found that 20 grs. of the green root will render 1 gallon of water sufficiently poisonous to kill fish. The first effects of the poison on a fish are to cause it to make violent efforts to escape, jumping

* This should probably be *D. Forsteniana*, Miq., which is now regarded as the same as *D. uliginosa*, Benth. See *Jour. Linnean Soc.*, vol. iv. Supplement.

out of the water, rapidly swimming about, etc. Then the breathing becomes labored and there is a sluggishness and uncertainty of movement; the next symptom is an increasing inability to maintain the ordinary position; then the fish turns on its back, rises to the surface, and the breathing becomes slower and finally ceases. When fish have reached the stage of turning on their backs and rising to the surface, they will, if put into fresh water, slowly revive and after the lapse of some hours appear little, if any, the worse for the experiment. I have three times poisoned a fish, allowing intervals for it to revive; and it has lived in an aquarium for days or even weeks afterward.

The poisonous principle is not, as might be expected, an alkaloid. I at first tried the usual methods for separating these substances, but the residues from the exhaustion of both acid and alkaline aqueous solutions by ether and chloroform did not possess toxic effects. After many experiments I found that the poisonous principle, for which I propose the name "tubain,"* is a very brittle, reddish-brown colored, resinous substance, quite insoluble in water, paraffin oil, and benzine, but soluble in alcohol, ether, and chloroform. It has a specific gravity of 1·1662; is dissolved by nitric acid, forming a bright dragon's blood red solution; and is unacted on by strong boiling solution of carbonate of soda. When heated in a glass tube it melts, boils, and then carbonizes, a brown-colored oil condensing on the cool part of the tube. It burns with a large smoky flame, leaving a quantity of carbonaceous ash. Fractional distillation and other means would perhaps break up the resin into several distinct substances, only one of which may be the virulent body; but my very limited laboratory appliances prevent me from carrying on the investigation further than I have done; and I must leave to others the further working out of the subject.

Tubain is most conveniently prepared by crushing up the chopped root and digesting it, with little heat, for some hours in alcohol acidulated with hydrochloric acid, filtering and evaporating on a water bath at a low temperature until a gummy substance separates. When all the spirit has evaporated and water only remains, the tubain may be removed and pressed into a mass. This can then be washed by kneading in hot water and further purified by resolution in alcohol and repeating the above process. The result will be the resinous substance above described. The roots should be digested a second time in fresh alcohol. The dried root yields 9·42 per cent. of tubain by the above process. When tubain is dissolved in spirits of wine and left to stand, a granular deposit of a dirty white color is formed, which is only sparingly soluble in cold alcohol, but is dissolved by hot alcohol, chloroform, and ether. This granular body redeposits on evaporation from ether as a pure white crystalline, tasteless mass. From its solution in chloroform it is left as a clear white varnish. When heated it melts into a transparent white fluid, which on an increase of heat turns brownish-red and partly distills, unaltered. This substance when freed from all traces of tubain is not poisonous to fish. The acid aqueous solution left after the deposition of the tubain, and which contains presumably any alkaloids present in the roots, is also not poisonous.

One part of tubain in 350,000 parts of water proves quickly fatal to fish, and water containing the extraordinarily small quantity of one millionth, *i. e.*, 1 grain in 143 pounds of water, will kill fish in from one quarter to half an hour, according to species. There is a considerable difference in the susceptibility of various kinds of fish to the effects of the poison, and the *siluridæ*, or cat fishes, appear to be the most tolerant of any. It has been stated that fish killed by *Aker tuba* are sometimes unwholesome, but when we see the extremely small amount of poison which is required to produce a fatal result, it seems improbable that any ill effects can be produced by eating fish so killed; the more so as tubain distills over with the steam from boiling water and would be, in part at least, eliminated in cooking. The crushed roots, when boiled with water in a retort, yield an opalescent distillate, smelling strongly of the root, and actively poisonous. The Malays say that fish killed by means of *Aker tuba* very quickly go bad; but unless the poison acts as a chemical ferment, which seems unlikely (as tubain added to milk causes no change, and, if anything, rather retards its turning sour), it is more probable that the idea arises from comparing fish caught alive and remaining so in the bottom of a boat, for some hours perhaps before they actually die, with those killed by the root at the time they are taken out of the water. In the case of fish, the poison is evidently absorbed by the gills, and passes at once into the circulation of the blood, which probably accounts for the infinitesimal doses which are enough to produce lethal results; for with most poisons this is by far the most effective way of administering them. Owing to the insolubility of tubain, it may be eaten by a fish with impunity. I have seen a fish eat enough to kill a score without any ill effects; but when a solution of it in spirits of wine is added to water, although the tubain is at once precipitated as a bluish-white cloud, still it is then active. Presumably, the fine state of subdivision enables it to be assimilated by an animal organism. In the sap of the plant it exists as an emulsion; and the sap, having no tendency to coagulate, may be diluted to any extent with water. By this means it becomes an extremely attenuated emulsion. When the roots have become dry, this only takes place to a very limited extent; and a solvent is then necessary to bring the tubain into a form in which its poisonous qualities can be applied.

There appears to be no reason why we should not take the hint from the Chinese market gardeners and apply the poison to the destruction of the many insect pests to which garden and greenhouse plants are subject.

From what has been said as to the nature of the substance it will be apparent that the dried roots would be of little or no good for the purpose, and the tubain must, after being extracted from the root, be converted into an emulsion or into some chemical combination easily dissolved in water. By the aid of a small quantity of spirit it may easily be emulsified with soap, which on solution in water presents the

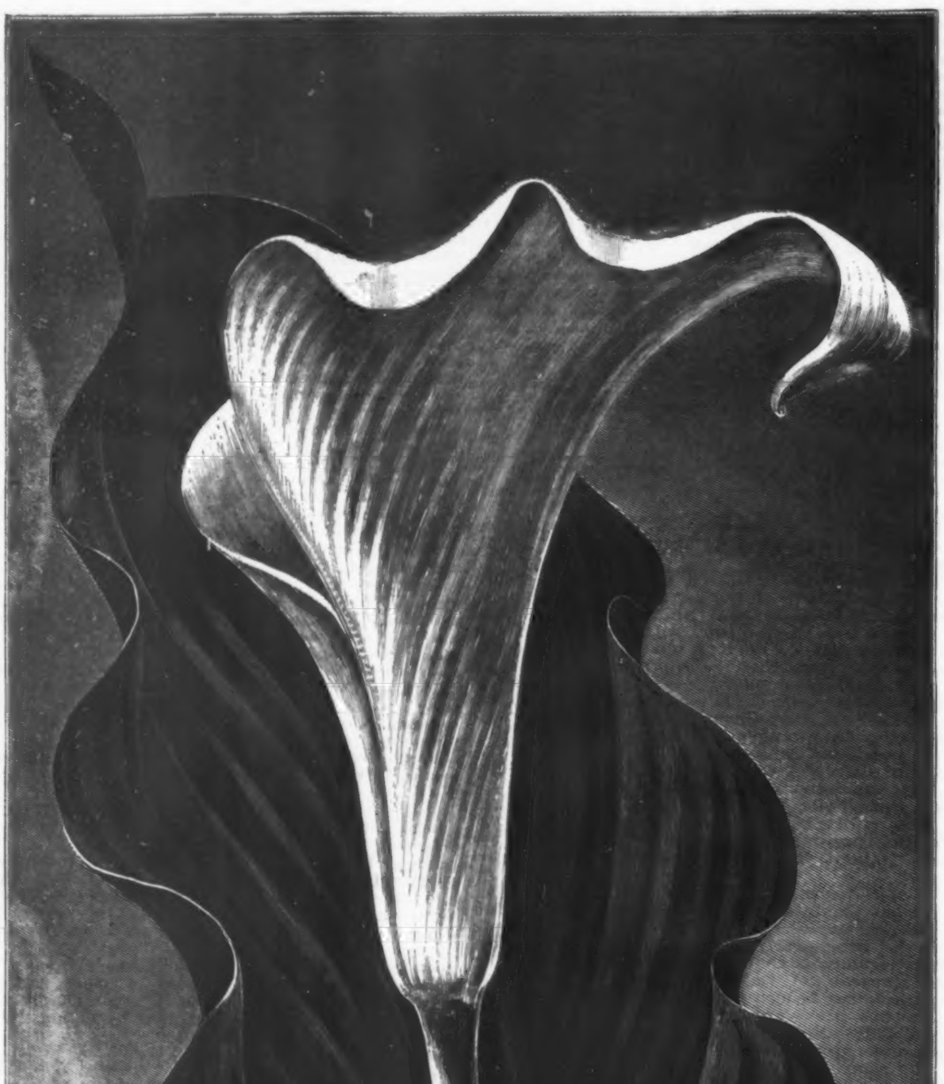
* Mr. Wray appears to have worked in ignorance of M. Greshoff's discovery of "derrid." See *Pharm. Jour.*, [3], xxi., pp. 550-560.

poison in an active form. I think it may also be saponified if mixed with oil before it is treated with alkali. My attempts in this direction have been only partially successful as yet. In both cases potash or soft soaps would be the most convenient vehicles with which to combine it, as they are so much more readily miscible in water than the soda soaps. The extraction of the poison from the roots in a large way would not be costly, as by suitable apparatus the spirit could be distilled off and used over and over again; and doubtless some cheaper method of extraction could be found. The plant grows steadily in the Straits Settlements. The roots are dug up from time to time and the stumps and suckers are replanted and soon throw out new roots. The stems also contain the poison, though in not so great a proportion, but still worth extraction. It is probable that the best time of year to harvest the root would be in January, as the plant is then at rest and nearly leafless. This is a subject which seems to be well worth the attention of the makers of insecticides and of floriculturists and horticulturists generally.*

* See also "Kew Gardens Report," 1877, p. 48, and *Pharm. Jour.* [3], xvii., p. 5.

CALLA PENTLANDI.

WE recently recorded the fact that the floral committee of the Royal Horticultural Society had conferred a first-class certificate upon this remarkable calla, and stated that it had proved a veritable surprise to the large body of horticulturists present. We have now much pleasure in giving an illustration of it, which so clearly shows the character of both the foliage and spathes as to render a lengthy description quite unnecessary. At present, practically nothing is known of its origin; but it may perhaps be assumed that, like the highly valued Calla æthiopica, which was introduced as far back as 1731, it belongs to the South African flora. A careful examination of the plant, however, shows that it is very closely allied to the species named, and it would probably be correct to describe it as a form of it, differing only in the rich golden hue of its spathes, and therefore of immense value as a companion. It is perfectly distinct from C. Elliottianum, which was sold the other day at Protheroe & Morris' rooms for a comparatively large sum, that form having leaves marked with translucent white spots, and evidently allied to C. hastata, a species introduced in 1859, and producing greenish yellow spathes. It has, indeed, been conjectured that Elliott's calla is a hybrid between C. æthiopica and C. hastata, but as yet no evidence has, so far as we are aware, been forthcoming in support of that hypothesis beyond that afforded by the plant itself. With the parentage of C. Elliottiana we are not now concerned; and with reference to that of C. Pentlandi it may be safely assumed that, whatever may be its parentage, it is unquestionably one of the finest of the ornamental plants introduced to public notice during the current year, and Mr. Whyte may be heartily congratulated on the possession of such an important and beautiful novelty.



CALLA PENTLANDI.

As regards the history of Calla Pentlandi, it appears that about two years since a friend of Robert Whyte, Esq., Pentland House, Lee, gave him a few tubers, stating that they were callas, and that he believed one of them might prove to be a yellow variety, and some mention was made of one having spathes of a rose color. Mr. Reece, the gardener at Pentland House, had the roots placed under his charge, and in due course they all produced leaves, and two bloomed, but the spathes were very small and poor, and white like those of the type. About a month from the date of the publication of these notes another plant gave indications of blooming; and a few days before the meeting of the Royal Horticultural Society, at which it was shown, the fine golden spathes, so well portrayed in the accompanying illustration, attained their full development. Mr. Whyte at once decided to exhibit the plant with a view to obtain an authoritative opinion as to its merits; and the high opinion formed of it by the committee to which it was submitted is shown by the fact that it received the highest distinction it was in their power to confer.

With reference to what has been written about golden callas since C. Elliottiana passed under the hammer, Mr. Whyte observes: "I notice several horticultural papers comment on the point that at the recent sale of Calla Elliottiana the existence of another yellow calla was known. I am inclined to look upon this wisdom as being of the class that is more common than a yellow calla, its chief feature being its declaring itself after such knowledge has become public." Mr. Whyte further remarks: "It may be interesting to note that the callas I have die down each autumn. I have still a plant which has not yet flowered; its foliage appears to be precisely the same as C. Pentlandi, and I look forward with some interest to seeing it in bloom. C. Pentlandi is sending up another spathe." The interest with which Mr. Whyte and his gardener are anticipating the production of spathes by the plant that has not yet flowered in the gardens of Pentland House will, we are quite sure, be to some extent shared by many of our readers.—*The Gardeners' Magazine.*

[NATURE.]

ON THE CAUSES OF THE DEFORMATION OF THE EARTH'S CRUST.

MOUNTAIN MAKING.

BY eminent geologists it has been shown that the contraction hypothesis is not sufficient to account for the observed deformations of the earth's crust. We are obliged to look for other causes of deformation.

The form of a cosmic body must be irregular if the masses are unequally mixed. Already in the liquid stage under this condition a geoid is formed. The radius with dense material must be shorter, so much as to equilibrate the higher regions with less density.

This cause of constant irregularity is not sufficient to explain the existing differences of level. In fact, depressions and elevations are not the result of a constant equilibrium; they are not permanent. Sedimentation and erosion disturb the mechanical and the thermal equilibrium and cause a continual deformation of our planet.

Another cause of deformation is found in the continual shifting of material. Accumulation of eruptive material and of sediments (loading) on one side, and erosion (disburdening) on the other side, cause deformations of the earth's crust. If the plasticity of the cosmic body is great, the surface of the burdened and disburdened regions has the tendency to remain nearly level—a quasi-hydrostatic (a "magmastatic") equilibrium will dominate.

As the material of our earth is not very plastic, and as other causes of deformation have a contrary effect, it is natural that geological facts are not in accordance with this hypothesis.

Contradictory to this hypothesis are the facts (1) that subsidence does not continue as long as sedimentation goes on; (2) that sinking often is considerable, though the loading is slight; (3) that in many cases enormous loading does not produce a depression of the earth's crust (volcanic chains growing up on a highland).

THE THERMAL THEORY.

The constant disturbance of thermal equilibrium is of the highest importance. Sedimentation causes an ascending movement of the geo-isotherms; expansion and general elevation. If the dilatation is concentrated, there may result a fold chain (Hall, Reade). The hypothesis is supported by the fact that the elevation and folding always drives up sediments, which were formed immediately before the orogonic movement. The mountains grow up from a shallow sea; they never generated in the middle of a continent, which might as well occur according to the contraction hypothesis.

Messrs. Fisher, Hutton and Reade have considered the thermal effect, and agree that it is sufficient to produce considerable deformations. But to produce a mountain chain of some 1,000 m., we must suppose a concentration of the effect in one zone, as long as we, according to Mr. Reade, consider only the effect of thermal expansion in the earth's crust.

As physical geology considers the earth as a rigid body (the plasticity, according to Mr. G. Darwin, being that of steel), there is no reason why the thermal expansion ought not to proceed through the rigid magma to the region of constant temperature. The increase of temperature being 3° C. for 100 m., the temperature at the depth of 40 km. = 1,200° C., at 50 km. = 1,500° C. After sedimentation of 10 km. the base of the sediments is warmer by 300°. The underlying masses are equally warmer by this quantity.

The linear expansion of rocks per 100° C. is nearly = 1 per mille, *i. e.*, 1 meter per km. In our case the expansion is = 3 m. per km. Lateral expansion being impossible, it results in a vertical elevation of nearly 1 per cent. The *crust* would be elevated through the full expansion by 500 meters.

If we consider the thermal expansion proceeding to a depth of 500 or 1,000 km. through the rigid magma, we find that indeed highlands and chains of some 1,000 m. may be driven up, even if we do not suppose a concentration of the thermal effect on a restricted zone.

Yet certain facts are not in accordance with the theory thus formulated. (1) Elevation and mountain making is not a slow and constant process, but it is executed in a short time (relatively). (2) Folding in some cases does not reach to a considerable depth, but we often meet undisturbed masses below the folded

complex. These facts induce us to modify the hypothesis.

Messrs. Gilbert and Suess have shown that the movement of folding is horizontal and superficial; we may consequently ask whether folding may not be caused by a *gliding* movement (see my "Theoretical Geology").

If we deposit under water sediments of great plasticity, and if we incline afterward the masses to the extent of 5° or 10°, there succeeds a gliding movement, especially if the sediments partly emerge from the water level, and if occasional shaking (earthquakes) occurs.

The gliding masses form a fold chain. The Silurian

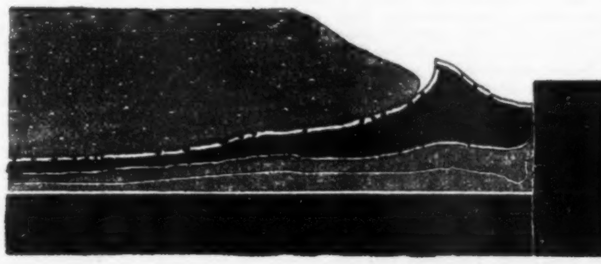


FIG. 1.

of Christiania is intensely folded, but it rests on an undisturbed base (Brogger). The folded Jurassic strata of the Weser chain likewise repose on an unfolded base. In such cases it is impossible to derive folding from a general contraction, nor can we explain the quiet base by supposing a concentration of thermal expansion in certain districts. The existence of a quiet base is explained only if we admit folding to be in such cases a gliding process.

The fact that folding in nature is accompanied by emersion is in accordance with these views.

Contradictory to this hypothesis seems the fact that the hypothetical land (from which the folded sediments were pushed toward the lowland) in the back of the chain is often wanting, and that in its place a (marine or a terrestrial) depression exists. This objection disappears if we pursue the process, and we find that this seemingly contradictory fact indeed must result: partial cooling causes local depression. Erosion has the same effect. If 1 km. (vertical measure) of rock mass is denuded, the temperature of the new surface is lower by 30° C. than it was at this point before erosion occurred. This cooling propagates into depth and the denuded land gets depressed.

The highland, from which the sediments glide away, must sink down in course of time. The Jura is pushed toward the French plain; in the back is situated the depression of Neuchatel. Here, according to the deduction, existed a highland, which subsided in consequence of cooling. Between the fold chain and the depressed district are situated deep ruptures, along which earthquakes occur as long as the depression goes on.

East of the Appalachian Mountains, as late as the end of the Palæozoic era, a highland was situated, wherefrom the detritus masses were transported into the Appalachian Sea. Afterward the carboniferous emersion occurred (in consequence of thermal expansion) and the Palæozoic sediments were pushed toward the western lowland; here the Appalachian chain was generated. Erosion and consequent cooling, instead of the old elevation, caused a depression in the eastern region, which got inundated by the ocean.

In course of time the adjoining districts have changed parts. In the lowland a chain is driven up and the old highland sinks down.

Eruptive districts form depressions with growing accumulations. The thermal effect in course of time leads to an opposite movement. Material of 1,000° C. flows through many fissures and covers the surface. The eruptive region, in consequence, gets heated in a higher degree than by simple sedimentation. The period of depression in this case, too, in course of time, gives way to a contrary movement.

It is obvious that elevation and subsidence, in volcanic as well as in sedimentary districts, must alternate, as we indeed observe. Compression, metamorphism, and loading cause a negative movement in the sedimentary districts (geosyncline); warming causes elevation; erosion again creates subsidence. These positive and negative factors at different times have different values, and partly compensate each other. Therefore elevation and subsidence are often observed to alternate.

The greatest contrasts must occur where a highland joins the sea; here sedimentation and erosion cause a considerable shifting of material; loading and unloading, as well as great thermal contrasts, dominate in these regions.

The positive and negative movements of the sea level are not important; but the amplitude of deformation at the boundary between high land and sea is in some cases as great as 20,000 meters.

The hydrosphere is relatively constant, whereas the crust executes oscillations of long duration and great amplitude.

If we want to study in an experiment the formation and motion of a lava stream, it cannot be our wish to observe the motions of an enormous quantity of a body as viscid and as hot as lava through long time; that would be mere observation, and not experiment. In a real experiment we observe the motion of a small quantity of a less rigid material for some hours or days.

If we observe in nature folded strata of hard sandstone and of soft shale or clay, we shall be satisfied to imitate the deformation of the latter masses; and instead of the hard sand-tone, we will take substances as unplastic, but so brittle that they yield to the small forces employed in our experiment.

So we may produce on a small scale, with application of little force and in a short time, the same effect which we observe in nature on a large scale.

If we succeed in producing experimentally the same phases of deformation, the same mechanical effect as in nature, if we see fold chains and complicated eruptive massives growing up with their characteristic features, we shall be obliged to attribute to these experiments a high importance for mechanical geology.

In my experiments I evaporated muddy material (clay, mud) or plaster of Paris, which consolidates slowly in consequence of an admixture of glue. The strata were differently colored; some thin strata, consisting of plaster powder, were brittle, and underwent ruptural deformation, whereas the other masses showed plastic deformation. The whole system reposed on a base, which, according to the plasticity of the material, was inclined by 5° to 15°.

As soon as the inclination attained a certain limit, the whole complex begins to glide toward the lowland.

The sediments get folded to a considerable depth; faults occurred between districts of diverse motion. The gliding deformation occurred rapidly whenever the base was shaken slightly (earthquakes). The experiment being finished, we let the masses consolidate; afterward we may prepare profile cuts, which may be executed with the saw, if we evaporated plaster.

The cuts are instructive, if the strata are differently colored.

If we mark certain points in the originally level strata, or if we divide the whole system into cubes, we

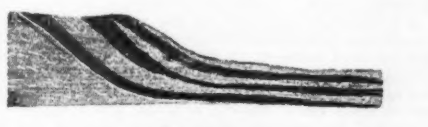


FIG. 2.

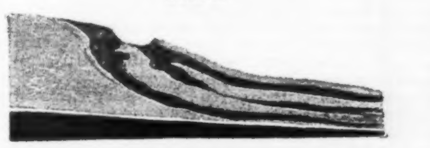


FIG. 3.

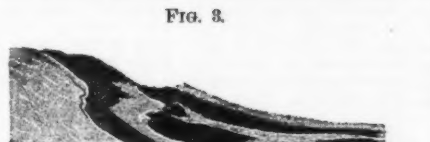


FIG. 4.

may study the locomotion and deformation of every point, line, square, or cube of our system; the vertical as well as the horizontal component of displacement may be observed and measured.

The following experiments explain some points in this theoretical essay:

The plastic sediments are loaded by a mass, and get deformed in the manner illustrated by Fig. 1. The black base and the black side wall at the right hand (fault scarp) are rigid; the plastic strata are pushed up in form of a fold; the highest white stratum is rigid, and gets torn into clods.

Figs. 2-4 show successive stages. A delta, deposited under water, gets elevated, it emerges; the masses are shaken slightly and glide over the inclined base. Folding succeeds, as Figs. 3 and 4 show.

In Fig. 5 the strata, gliding over the inclined plane to the left, were divided by vertical lines. Distance of

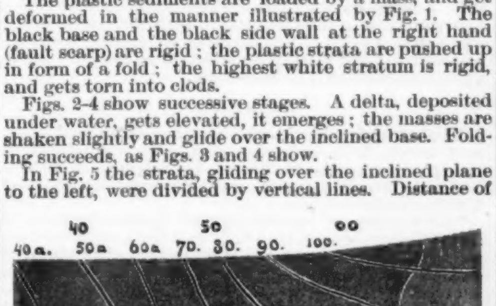


FIG. 5.

lines = 0·1 meter. At the top of the figure the fixed scale is noted. Point 40*a* of the strata originally lay directly below the scale point 40, 60*a* was placed below 60, and so on.

We see at once the amount of horizontal (gliding) movement. The vertical lines are deformed in the direction of the motion. The parts near the base move little, the parts near the surface have a higher velocity, so that the vertical lines of division get curved. The motion being intense in the highland (at the right hand), the vertical lines in this region are pushed over and assume a flat position.

The surface of the gliding masses in this case remained level, as the material was very plastic; yet folding in the depth of the masses is remarkable. We see that a fold chain may have a wide surface; the intensely folded regions get exposed only after an extensive erosion or abrasion occurred. This experiment shows also how the motion and the amount of folding decrease in the direction toward the base.

Figs. 6 and 7 illustrate my conception of the process of glide folding as it occurs in nature. The black parts form the solid basement; at S, we observe a fault scarp (the coast of a continent). In the sea the sediments,

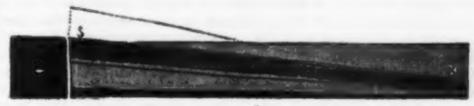


FIG. 6.

SX, are deposited. Warming of the newly deposited masses, and of the lower parts of the earth's crust, in course of time elevates the sediments, as the dotted line in Fig. 6 notes. The sediments glide over the

FIG. 7.

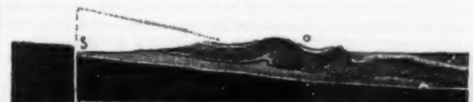


FIG. 8. FIG. 9.

inclined plane toward the right, and form a fold chain, O.

The motion of a single point is noted in Fig. 8. Point S first gets elevated (through thermal intumescence) to S', and then it glides toward S''. In most cases the way described by a point is complicated, as Fig. 9 illustrates. Elevation having reached a certain degree, the masses glide a little, elevation continues, again gliding succeeds, and so on.

The highland in the back of the fold chain (black mass at the left hand) gets eroded; cooling causes a subsidence of this region, the earth's crust breaks, and through the fissures and faults, in many cases, eruptive material escapes. A volcanic chain is built up in the back of the fold chain (Fig. 10). In course of time

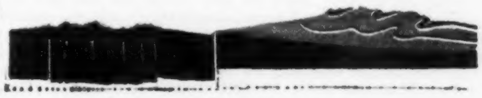


FIG. 10.

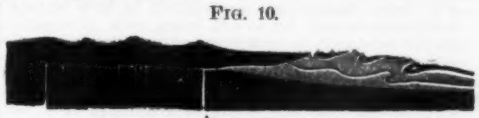
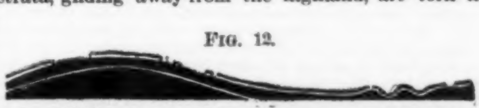


FIG. 11.

the fold chain may be covered partly by the volcanic chain (Fig. 11). Fig. 12 (profile) and Fig. 13 (surface of the same experiment) show that pulling (tearing) and pushing (folding) are *reciprocal processes*. The strata, gliding away from the highland, are torn in

FIG. 12.



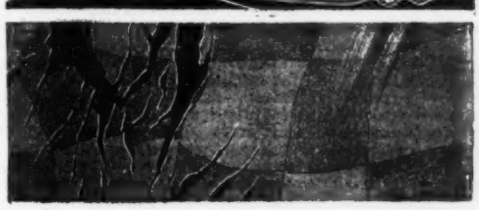


FIG. 13.

this district, whereas compression and folding occur in the lowland.

The surface of the strata (Fig. 13) was divided into squares of different color (like a chess board), so that we may see and measure directly the direction and amount of pushing and pulling in both districts. Black fissures occur at the left hand, gray folds at the right hand.

The base in this, as in the other cases, was rigid; there occurred *no compression in the depth*, yet folding succeeded in the gliding strata.

Folding, according to my opinion, does not depend on a contraction of our planet, but is a simple gliding phenomenon. E. REYER.

ACCORDING to the *Pioneer Mail*, the port officer of Mangalore reports that a native craft was overtaken by heavy weather and made for Mangalore, where there is a bad bar with about 8 ft. of water on it. A tremendous sea was breaking over the bar, so, before crossing it, and while running in, the native skipper opened one oil cask, forming a part of the cargo, and scattered it all round in the sea plentifully, with the result that he took his craft across the bar safely, and so saved the vessel and the cargo. The vessel's name was Mahadeprasad, and she was of 95 tons, bound from Cochin to Bombay.

ON THE PRACTICAL TEACHING OF CHEMISTRY IN SECONDARY EDUCATION.

By GUSTAVE MICHAUD, Sc.D.

THERE is a strong tendency, in modern education, to be mindful of the child's intellectual organization and to modify the teaching according to its requirements. Empirical sciences are taught and learned as they were made, that is to say, proceeding from the concrete to the abstract, from the known to the unknown, from facts to laws. That form of teaching may not seem to be the most logical; it is the most fruitful. When teaching geography, the shortest and straightest way may seem to be, first to give an account of the form of the earth and of its relations to other planets, then a brief description of the continents and oceans and last to pass to the study of the various countries. Experience shows that such teaching conveys little more than meaningless words to the child's mind. On the contrary, if he is told about the objects in the immediate neighborhood of his house, then about the surrounding of his town or village and afterward about his country, he can compare that which precedes with that which follows and understands what he is learning. The shortest way between two points is not always the straightest. If it were so, there would be no such phenomenon as the refraction of light.

The first elements of language, geography, botany, zoology, are now generally taught according to the natural principles of the analytical method. Although the teaching of the elements of the physical sciences is not quite so advanced, the same method has been followed in some excellent text books published principally in the United States and England. I wish to show its advantages in the teaching of a branch to which no attempt has yet been made to apply it, viz., the practical teaching of chemistry.

Chemistry is a practical science, the methods of which cannot be fully understood without a certain amount of practical work. Nevertheless, such are the difficulties which we encounter when we desire to give a practical training in chemistry to young pupils that only a few secondary schools have a chemical laboratory and compel their pupils to do chemical work for themselves. I believe most of these difficulties could be easily overcome if we were to apply a method more in accordance with the teaching of modern pedagogy.

In those secondary schools where pupils are exercised in practical chemical work, but two distinct classes of work are undertaken: 1st. The preparation of those important inorganic compounds the molecule of which is composed of but a few atoms. 2d. Very simple analyses of salts, which generally do not go beyond the qualitative determination of one metal and one acid radical. Both courses comprehend chemical synthesis and analysis, that is to say the rupture and the construction of molecules. Instead of these courses I would propose one in which *molecules of distinct nature, such as are found in natural organic compounds and more especially in plants, would be not decomposed, but isolated.* Instead of making up or destroying chemical compounds, the student would separate bodies existing as natural organic mixtures. Before learning how to decompose ammoniac gas, how to detect manganese compounds or how to make hydrofluosilicic acid he would learn how to separate gluten from starch in corn flour or how to isolate the cellulose contained in a sample of hay. *Proximate* organic analysis would precede elemental inorganic analysis or synthesis. Such a course would be truly analytical, not only from a chemical point of view, but, above all, in the pedagogical meaning of the word. The advantages are obvious, and, among them, I desire to mention the following:

1. *The proximate method leads the pupil from the known to the unknown.* With the actual laboratory teaching the pupil is immediately brought into the presence of numberless chemicals, such as barium nitrate, ammonium molybdate, potassium permanganate, etc., the properties of which are as strange as their names. He has never heard of them in his everyday life. He cannot compare them with those bodies he meets constantly in Nature's vast laboratory. In the first practical steps in chemistry, as well as in the theoretical, the choice of such compounds to illustrate chemical phenomena openly violates an important law of pedagogy. Such a reproach cannot be made against the method I propose. According to this plan the pupil begins by operating on bodies he is completely or partially acquainted with. Most of the compounds separated, such as starch, sugar, grease, casein, gum, resin, have been frequently seen in various forms by the student, who is fully acquainted with some of their properties. Most of the reactives used to extract them from the natural mixtures in which they are found are frequently used for domestic or industrial purposes, and consequently are known to the pupil.

2. *It enriches the mind of the pupil, not with technical notions, which will be useful only to the few who may continue the study of chemistry, but with practical notions immediately available in common life, and consequently useful to the greater number of pupils.* It is almost superfluous to state that I do not pretend that the proximate method should take the place of elementary mineral analysis or of the preparation of inorganic bodies. I only affirm that it should precede them both. It should precede them not only because the laws of pedagogy require it, but also because, if it be the only practical chemical course presented to the pupil, it is the most useful. To those students who may never go further in their studies than what they may learn in secondary schools the knowledge of the preparation and properties of a legion of rare inorganic bodies is of little avail; what they want to know are the properties of those organic compounds the theoretical value of which is perhaps insignificant, but which have a great practical importance because our food, our dress, and our own bodies are composed of them.

3. *The proximate method is comparatively easy and does not present such practical difficulties as could not be overcome by beginners.* The operations performed in order to separate the organic constituents of plants and animals are of the very simplest description, and consist mainly in dissolutions, that is, in operations the pupil sees daily at home. The teacher who follows that method gets rid of the practical hindrances which arise when teaching beginners the mode of using the complicated apparatus required in the preparation of the commonest inorganic bodies.

4. *It requires only the very cheapest apparatus and chemicals which may be found everywhere.* The cost of a chemical laboratory, the necessity of frequently renewing high priced chemicals and easily broken apparatus is perhaps the principal hindrance to a general introduction of practical work in the secondary teaching of chemistry. As a consequence of their simplicity, most of the operations of the proximate method can be performed, if necessary, with the use of culinary utensils and with chemicals to be obtained at the grocer's. The list of these products and apparatus will be given below.

5. *It does not comprehend experiments so dangerous as those which are made during a practical course of chemical inorganic preparations.* Experiments that are free from danger to the professional chemist may be dangerous to the pupil who makes them for the first time, and the feeling of a heavy responsibility compels the teacher to exercise a vigilant care, which unnecessarily complicates his work. During a course of chemical preparations, these dangers are met with from the beginning. The first preparation is generally that of hydrogen. It is not uncommon to see a pupil pour as much sulphuric acid on his hand as into his apparatus. Others have seen the professor lighting the gas as it escapes from the bottle and think there is nothing to prevent their doing the same at the very beginning of the operation. The preparation which usually follows, that of oxygen, is perhaps still more perilous, and but few of the preparations of inorganic compounds or elements are altogether exempt from danger. The proximate method is nearly free from the risks which attend the use of dangerous bodies by inexperienced hands. No inflammable or poisonous gas is prepared, no explosive bodies are used. The only possible cause of accident is the use of inflammable liquids, such as lamp oil and alcohol, but this danger is familiar to every one and consequently easily avoided.

I believe that every chemist who has had to teach laboratory work will fully understand the importance of the preceding statements. In order to fully prove them I will enter with some detail into the description of the method itself, with the hope that this explanation may help the teacher willing to give it a trial in overcoming the difficulties he might meet with while carrying it out.

A laboratory devoted to the proximate analysis of plants can be installed in any room provided it be well lighted and have a supply of water. The furniture should consist of a large table and two small ones. On the large table should be placed most of the apparatus, and a shelf on it should contain the reagents. This table will be used for general work. One of the smaller tables should be placed near the windows, and on it should stand the microscope and the balances; it may also be used as a writing table. On the other small table should be placed those apparatus likely to shake or jar the objects before mentioned (screw-press, mortar, rasp). It may be placed in a remote corner. The following list gives the necessary apparatus and reagents. It is calculated for a class of about twelve pupils. Should the class be more numerous, the glass and porcelain apparatus ought to be increased in number, while other apparatus, such as the microscope, the screw-press, the balances, can be used by over forty pupils. Should the pupils be very few, and should great economy be necessary, many apparatus, such as the screw-press, the microscope and one of the balances, may be omitted.

APPARATUS.

Three beaker glasses not lipped and three with lip; three flasks with round bottoms and three with flat bottoms; three conical test glasses; three glass funnels; three evaporating porcelain dishes; half a dozen glass stirrers; a mortar and pestle, in porcelain; a large copper basin; a test tube support with tubes; a cylinder on glass foot with lip, graduated in cubic centimeters; a separating receiver with stop-cock and stand; a graduated pipette for delivering exactly 10 cubic centimeters; Mohr's burette with support; a chemical thermometer graduated to 300° C.; a steel spatula; a rasp; a small porcelain crucible; an iron water bath; a sieve; a still; a support with three rings; a balance to carry 1,000 grammes in each pan and to turn with one gramme when thus loaded; ditto to carry 30 grammes in each pan and to turn with one centigramme; a screw-press; a plain microscope; a densimeter.

CHEMICALS.

Alcohol, hydrochloric acid, basic acetate of lead, acetic acid, iodine, lime, soda, ferric chloride, chloroform, filtering paper, ammonia, litmus, dry raspings of ox hide, benzene, tannin, gelatine, salt, Schweitzer's solution, Fehling's solution, gasoline.

The selection of suitable organic bodies for analysis should be made with regard to two important factors, viz.: 1st. The necessity of slowly graduating the difficulties. 2d. The advisability of choosing bodies that we meet with on our farms, in our factories, or in domestic life. It is evident that a list of such bodies must vary for many reasons, the principal one being differences in the relative importance given to plants according to the agricultural region in which they are grown. Therefore, the following series of analyses must be considered merely as a fair example of one of the numerous combinations that might be made:

First analysis. Separation of the starch contained in a sample of potatoes. Determination of its weight. About 500 grammes of potatoes are cleaned, weighed and rasped. The raspings are mixed with water and passed through a fine sieve. The deposit of starch is collected, dried and weighed.

Second analysis. Separation of the gluten and starch contained in a sample of corn flour. Determination of their respective weights. 200 grammes of corn flour are mixed with a little water and placed in a piece of linen. A knot is made in order to prevent the escape of this paste. After kneading for an hour in some ten liters of water, the gluten left in the linen is dried and weighed. The starch is collected and its weight determined as in the preceding analysis.

Third analysis. Separation of the fat contained in a sample of cocoa. Determination of its weight. 100 grammes of ground cocoa are placed in a separatory funnel and extracted after the method described further on, for the determination of the weight of fatty matter in vegetables.

Fourth analysis. Determination of the weight of tannin contained in a sample of oak bark. 50 grammes of finely ground oak bark are extracted with one liter of boiling water, the water being poured little by little on the bark contained in a separatory funnel. Tannin is determined in the filtrate after the method described further on.

Fifth analysis. Preparation of essence of cloves. Determination of the weight of this essence contained in a sample of cloves. 100 grammes of cloves are distilled with water and the essence determined as described further on.

Sixth analysis. Determination of the weight of sugar contained in a sample of beet root. 300 grammes of beet root are rasped and pressed. The juice is heated to 80° C., with a tenth part in volume of chlorhydric acid, and the sugar is determined after the method described further on. The figure obtained is that of the sugar contained in the juice. In order to know that contained in the root, it is necessary to multiply the first number by 0·96. The beet root contains 96 per cent. of juice.

Seventh analysis. Separation of the caffeine contained in a sample of coffee. Determination of its weight. 2 kilogrammes of finely ground coffee are mixed with 800 grammes of lime. The mixture is extracted with rectified alcohol. The alcohol is distilled. The extract is dissolved in alcohol at 50 per cent. After filtration, the liquid is evaporated until an oleaginous stratum is seen to float on the surface. This is separated and rejected. Then the evaporation is continued until the volume is much reduced. On cooling the liquid, the caffeine crystallizes. It is then dried and weighed.

Eighth analysis. Analysis of a sample of milk. The weight of one liter of milk is determined by means of a densimeter, and this quantity is evaporated to dryness. The weight of the residue allows us to calculate the percentage of water. This residue is washed with gasoline and weighed again. The difference observed in the two weights gives the percentage of butter. The matter is then washed with water, and the proportion of sugar contained in the aqueous liquid is determined with Fehling's solution. The percentage of caseine is found by difference.

Ninth analysis. Analysis of a sample of hay. The proportions of water, ashes and fat contained in a sample of hay are determined further on. Then 100 grammes of hay are ground several times with small quantities of water in a mortar. In the filtered liquid, soluble proteids, gums and sugar are determined as stated further on. In the residue cellulose and insoluble proteic matter are determined after the method described further on.

The pupil who has made the above series of analyses or any other in which the same gradation has been observed is now able to undertake original work. The unexpected difficulties he will meet with and overcome, sometimes alone, sometimes with the help of his professor, will complete his practical training, while the unforeseen and highly interesting facts he will sometimes discover will prove a powerful stimulus to him.

Mr. James Pyle Vickersham says:

"New discoveries in science and new inventions in the arts are still possible, and methods of instruction should prompt the young to make them. . . .

"I take it that education means something more than merely conning the facts and repeating the reasonings of text books. If properly instructed, pupils will desire to look beyond what they have been taught, or what they have simply learned. They will desire to do it. The highest aim of teaching is not to store the mind with the accumulated knowledge of ages, but to arm it with energy and skill; not to enable pupils merely to solve problems in mathematics, construe sentences in grammar, or answer questions in philosophy, but to inspire them with a love of study, to awaken in their minds an animating, life-giving power, that does not rest satisfied with present attainments but is ever striving to open up new truths, to express new beauty, or to contrive new ways of lessening labor or effecting good."

If the proximate method be followed, the greatest difficulties inherent to original work in chemistry can be got rid of. It is the special nature of the method that removes them. As observed before, the processes used in decomposing bodies widely differ from those put in practice in separating them from other substances, and whenever the first kind of work is applied to original research, it requires an amount of skill and knowledge to be attained only by years of study both theoretical and practical.

Moreover, none of the operations just enumerated requires great accuracy. The chemical methods used in the separation of organic bodies are far from being so precise as those used in mineral analysis, and the errors resulting from the inexperience of a beginner are generally smaller than those that arise from the imperfection of the method. Neither would greater accuracy be very useful in the proximate analysis, as it occupies itself with variable quantities, and as its purpose is to settle averages rather than isolated ciphers. In various fruits gathered from the same tree and identical in appearance, the proportion of pectine varies greatly. If the percentage found by the chemist in a fruit or in various fruits does not too nearly approach the minimum or maximum it may be considered as a fair representative of the percentage of pectine contained in the fruit, although it might not very accurately represent the quantity that existed in the particular fruit or fruits analyzed.

Any part of any plant is a suitable subject for original analysis. Except a few general facts and the composition of some of those plants which have alimentary, industrial or pharmaceutical properties, all is still unknown in the chemistry of the vegetable kingdom. Of course the method of analysis must vary with circumstances, and the talent of a good teacher consists in enabling the pupil to discern for himself the best way out of each emergency. However, a general method may be adhered to which may be modified according to the composition of the substance when this is known or foreseen, whereas, when this is absolutely unknown to the pupil, he should employ the method without modification. Various good methods have been proposed for that purpose in technical

works,* but a special condition of chemical work in secondary education, viz., the necessity of avoiding complications in the operations, even at an occasional sacrifice of accuracy, does not allow us to adopt any of these methods without modifications. Instead of them I propose the following method. It is far from being perfect, but, so far as I know, it is the only one that has been devised for secondary education and practically and successfully tested by pupils of sixteen years old.

First Operation. From 500 to 1,000 grammes of fresh matter are dried at 100 or 105° C. The operation can be performed with a drying bath or a water bath heated with a solution of common salt. The difference of weight before and after the operation gives the contents in *water.*

Second Operation. From 20 to 50 grammes of dry matter are burnt in an iron crucible in order to determine the percentage of *ashes.*

Third Operation. One hundred grammes of dry and pulverized matter are placed in a separatory funnel with 250 grammes of gasoline. A little cotton has been introduced previously into the lower part of the apparatus. Then this is carefully corked and stirred as often as possible. Two days afterward the stop cock is opened and the liquid is allowed to escape into a recipient. It is replaced by new gasoline, which is used in the same manner. After three extractions have been made the residue is squeezed dry in a screw press and all the liquids are collected and evaporated. The *fatty matter* remaining is weighed.

Fourth Operation. The matter left in the press is placed again in the separatory funnel with about 500 cubic centimeters of alcohol. After a few hours stirring, the alcohol is collected. A second and a third extraction are made with new alcohol. The residue is then placed in a press and squeezed dry. The fluid is reunited to that which resulted from the extractions and evaporated to a thick consistency. Then it is treated with water, which generally determines the formation of a precipitate of *resins.* This is collected in a weighed filter and dried. Its weight represents the percentage of resin contained in the dry substance.

Fifth Operation. The filtrate from the precipitate of resin is divided into two equal parts, I. and II. Part I. is treated with chloroform and a few drops of hydrochloric acid in a separatory funnel. After frequent stirring, the stop-cock is opened and the chloroform separated from the aqueous solution. Then it is filtered, in order to remove moisture, and evaporated to dryness. Should the vegetable contain a *glucoside,* it will generally be found, crystallized or not, in the residue. Its weight, multiplied by two, will give its percentage.

Sixth Operation. From 5 to 15 grammes of dry raspings of washed ox hide are introduced into part II. and left in a cool place. Two days afterward the liquid is filtered off and the raspings are left a few hours in some 10 liters of water. Then they are collected in a filter, dried at 100° C., and weighed. Their increase in weight, multiplied by two, is the percentage of *tannin* contained in the dry substance.

Seventh Operation. The residue from the fourth operation is extracted some ten times with a large excess of water. Then it is squeezed dry a third time, dried at 100°, and weighed. The tenth part of its weight is placed in a covered mortar with 200 cubic centimeters of Schweitzer's solution. The mixture is frequently stirred. After some 12 hours it is filtered in a funnel stopped with a tampion of asbestos, after which a little water is used to wash mortar, funnel and asbestos. The acetic acid is poured into the liquid until it is changed from a dark to a greenish blue. The precipitate is washed by decantation with a large quantity of water for two or three days. Finally, it is collected in a weighed filter, dried, and weighed. Its weight, multiplied by ten, is the percentage of *cellulose* contained in the dry substance.

Eighth Operation. Another tenth part of the water-washed and dried residue from the fourth operation is incinerated; the weight of ashes is added to that of cellulose found previous its multiplication by ten. The sum of both numbers is subtracted from the weight of a tenth part of the dried re idue from the fourth operation. The difference multiplied by ten is the percentage of *insoluble proteic matter* contained in the dry substance.

Ninth Operation. One hundred grammes of fresh substance are ground in a mortar with 500 cubic centimeters of water for several hours. This operation is repeated three times with new water. The water used is filtered and divided into two parts, I. and II. Part I. is heated to ebullition for a few minutes. If a precipitate be deposited it is collected in a weighed filter, dried and weighed. Its weight multiplied by two is the percentage of *soluble albumine* contained in the fresh substance.

Tenth Operation. A few drops of acetic acid are added to the filtrate from part I. Should a precipitate be seen, it will be collected and weighed as above, and the percentage of *caseine* calculated in the same manner.

Eleventh Operation. Part II. is evaporated till reduced to a small volume; then it is mixed with an excess of alcohol. The precipitate is collected and dried as above. Its weight, multiplied by two, is the percentage of *dextrine, gums,* and *pectic bodies* contained in the fresh substance.

Twelfth Operation. The filtrate from the preceding operation is distilled; all the alcohol is evaporated. The aqueous residue is heated for five minutes at 90° with a twentieth volume of hydrochloric acid and introduced into a graduated burette, then the *sugar* is dosed with Fehling's solution.

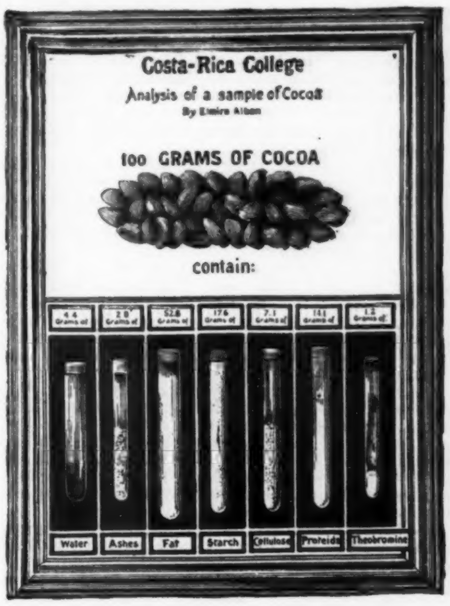
Thirteenth Operation. If the microscope show the presence of *starch* in the solution, from 300 to 2,000 grammes are rasped or ground, and treated with a large quantity of water, and the fluid is passed through a sieve. After a few hours, starch will be found at the bottom of the vessel. This starch is collected, dried, and weighed.

Fourteenth Operation. From one to five kilogrammes of finely divided matter are extracted, with from three to fifteen liters of hot water and a little hydrochloric acid. After filtration through a linen cloth, the fluid is neutralized with lime. The precipitate, mixed with lime in excess, is collected on a piece of linen, squeezed dry with a press, and dried at 100° C. It is then ground and extracted with hot alcohol. The fluid is filtered and concentrated. Should the plant contain an *alkaloid,* it will generally crystallize on cooling, and by weighing, its percentage can be calculated.

Fifteenth Operation. If the substance emit a strong aromatic smell, from 200 to 5,000 grammes should be distilled with water, and the proportion of *essence* will be found by collecting and weighing the drops of oleaginous matter found floating on the distilled water.

Sixteenth Operation. One hundred grammes of dry matter are directly extracted in the water bath with 100 c. c. of hot and rectified alcohol. If the cooling of the filtered liquid determinate the formation of crystals, the residue is extracted again with 500 c. c. of alcohol; the liquid which results from both extractions is filtered and concentrated. On cooling it will deposit the *mannite* and congeners (*dulcite, perseite*) contained in the plant.

A special feature of the proximate method is that it can be used to convey instruction and inspire a love of it not only to the pupil who has made the analyses, but also to the younger pupil who may be ignorant of the very word "chemistry." To attain that purpose it suffices that the result of the analysis be presented in an objective and telling manner. Instead of writing down the names and proportions of the substances extracted from the compound that was analyzed, the pupil will present them in nature after a suitable and suggestive plan. The compound that was analyzed and the bodies extracted from it are fastened directly, or contained in tubes, on a large sheet of pasteboard. The natural mixture comes first, then the bodies that it contains, and the aggregate weight of the latter must make up the weight of the former. The figure shows the arrangement of the whole.



Thus expressed, the result of a proximate analysis will be intelligible even to little boys, while it would have been perfectly meaningless to them had it been presented to them in the usual way. If it be suspended on the walls of a lower class room, it will be a help to them in the object lessons. Thus the pupils can be made to instruct their younger school fellows, and these can be gradually and directly prepared for the chemical work they will have to undertake later on. Given to its author, such a frame will constitute a means of instruction as well as a record of good work in former years.

Life is too short to follow the longest way in studying any branch of human knowledge. The results of the actual teaching of chemistry in laboratories are great difficulties presented to the teacher, lack of interest to the pupil, and loss of time to both. The reform I propose is not something new. It is but the extension to secondary education of the analytical principles now so generally applied to primary work. I hope that those teachers who know, by experience, the soundness of these principles will not hesitate in giving the proximate method a fair trial.

THE ADDITION OF SALICYLIC ACID TO WINE.

At the Great Marlow Petty Sessions, on June 23, before R. Hay-Murray and E. Clark, Matthew John Clifton, of Marlow, grocer, was summoned under the Sale of Food and Drugs Act for having sold, to the prejudice of the purchaser, some raspberry wine adulterated with salicylic acid and colored with Brazil wood. Mr. Wilkins conducted the prosecution and Mr. P. Rose-Innes, barrister, appeared for the defense.

Superintendent Sargent proved the purchase from Mr. Clifton's shop of a bottle of raspberry wine for which he paid 1s., on May 16 last. He was served by an assistant. He divided the wine into three parts, leaving one part with the defendant's assistant. In cross-examination this witness admitted that he had since purchased from Mr. Clifton's shop another bottle of raspberry wine for his own consumption.

Walter William Fisher, of Oxford, public analyst for Bucks, produced his certificate of analysis of the wine in question. He found it to contain about the usual quantity—20 per cent.—of proof spirit, with sugar, etc., and about 18 grains of salicylic acid. The wine was colored with what he believed to be Brazil wood. In his opinion salicylic acid was not a proper constituent of raspberry wine. It is a drug made from carbolic acid. Brazil wood is not present in raspberries, and was not, in his opinion, necessary for the manufacture of raspberry wine.

I never have been a manufacturer of raspberry wine. I do not remember having analyzed a sample of raspberry wine before this one. I am a Master of Arts, but have no medical degree. The test I used was white ribbon and gelatine. I used a variety of tests, and comparing the results with those previously obtained, I came to the conclusion that the coloring matter used was Brazil wood. I did not pursue my analysis to find cochineal. I know of no substance other than Brazil wood that would produce the color and effects I found. I am aware that cochineal is much used for cooking and coloring purposes, and that it is perfectly harmless. For discovering the salicylic acid I added perchloride of iron, which produces a violet color, which would indicate the salicylic acid or carbolic acid, but the last mentioned was entirely out of the question. I believe that salicylic acid stops fermentation. I don't know that it is largely used in this country. I have found it in beer, but I don't get many samples of beer to analyze, but of 1,700 analyses I have made I only found it in two instances. I have examined samples of wine in which salicylic acid was not present.

Mr. Hay-Murray—We are called upon to decide, not whether the salicylic acid is injurious or not, but whether it was in the wine or not.

Mr. Rose-Innes contended that there could be no offense when an article was necessary and was used for a commercial and not for any improper purpose.

In addressing the bench for the defense Mr. Rose-Innes said there was nothing to show that the acid was used for a fraudulent purpose. It was much more costly than the wine itself, and was simply used to prevent deterioration of the article. He also took exception to the certificate. It was provided in the 18th section of the act that the certificate should give the exact quantities of the ingredients found, which had not been done in this case. He should prove by the very highest scientific authority that the introduction of salicylic acid in proper medical proportion was not only not injurious, but absolutely beneficial to the wine with which it was mixed.

The first witness called for the defense was Mr. Granville Sharpe, who described himself as an analytical and consulting chemist.

He had analyzed this wine and found it to contain a large quantity of raspberry juice and a small quantity of salicylic acid, and nothing injurious to health. He detected some coloring matter and found it to be cochineal, which is perfectly harmless and frequently used to intensify color. He did not find any Brazil wood. The salicylic acid was in the proportion of about 2 grains to a bottle. In cross-examination he said he tested for Brazil wood, but did not find any. He did not test the residue. He was not told what to search for in the wine.

Professor W. Lascelles-Scott said he was a consulting analyst, lecturer on chemistry and hygiene to the London Conservatoire, consulting analyst to the Royal Commissions (C.I.E) for Victoria, the Mauritius, the India Museum, the West Riding Chamber of Agriculture, etc. He had held the appointment of public analyst for the counties of Derby, Glamorgan, North Staffordshire and the Borough of Hanley, and had had great experience in the examination of food products. He had analyzed this wine. There was no trace of Brazil wood in the wine whatever, and his tests would certainly have detected it had any been present. The color was due to the raspberry juice and a very small proportion of cochineal—a coloring matter largely used in improving the appearance of various articles of food and drink, as it was perfectly innocuous. Salicylic acid was also present in a very small quantity—700 fluid grains (one hundredth part of a gallon) of the wine only contained 0·165 of a grain of the acid, equal to 16½ grains per imperial gallon, or about 2¾ grains per bottle. This was a proper proportion and sufficed to prevent secondary fermentation in the wine and to keep it in a wholesome condition.

All wines containing a good deal of sugar and but little alcohol were liable to this change—raspberry wine especially—and needed some antiseptic to make them keep at all.

Salicylic acid being effective and not at all injurious to health, was one of the very best that could be used for the purpose.

He had obtained the salicylic acid by exhausting the wine extract with pure ether, and identified it by means of perchloride of iron and the microscope. The coloring matters he recognized by a number of tests, including the spectroscope, and the specimen of silk he produced would have been colored very differently were any Brazil wood present in the wine. Had such a sample been officially submitted to him during his career of public analyst, he should have undoubtedly certified it as being "Not adulterated."

Cross-examined, the witness said he had extracted the whole of the salicylic acid from the portion of the wine tested by exhausting it seven times with ether; of this the last two portions yielded no residue whatever. The salicylic acid was absolutely necessary to preserve the wine. He was instructed to search for the acid and for Brazil wood, but the latter was absent, while of the acid there was not "18 grains" in a bottle of the wine—only about 2 grains. He had frequently analyzed raspberry wine; this was a well-made sample. He had not "made" raspberry wine himself, but, as it happened, his wife had done so once.

Mr. Wilkins—And, pray, did she put salicylic acid in it?

Mr. Lascelles-Scott—No; but I did, to "keep" it. (Laughter.)

Dr. John L. W. Thudichum said: I am an M.D., M.R.C.S., and F.R.C.P., and Scientific Referee to the Board of Trade. I agree with Mr. Lascelles-Scott that the use of salicylic acid is necessary to prevent fermentation in wine, and that it is quite innocuous. Large quantities of the acid are used in food without injury from it. If a shilling's worth of the acid were put into a bottle of raspberry wine, no harm would follow to those who partook of it.

Dr. Bond said: I am lecturer to the College of Physicians. I have had long and extensive experience in the use of salicylic acid, and have been in the habit when away from home hunting in the country of tak-

* Among the principal, we wish to mention Wittstein's Anleitung zur chemischen Analyse von Pflanzentheilen, Draggendorf's Chemische Analyse von Pflanzen, and, above all, Prescott's Outlines of Proximate Organic Analysis. This last treatise seems to me to be more complete and more accurate than any of the similar French or German works.

ing 10 grains of the acid a day for a month without the slightest bad effect; the quantity mentioned as having been found in the wine could do no possible harm to any one.

After hearing the advocates the magistrates said they had come to the conclusion that no matter or ingredient was introduced into the wine to increase its bulk or to defraud or injure any one, and they had therefore no hesitation in dismissing the case.

ACETIC ACID FROM CELLULOSE AND OTHER CARBOHYDRATES.

By J. F. V. Isaac, B.A. (Oxon.)

Acetic acid has been frequently identified as a product of resolution by various agencies of the carbohydrates of lower molecular weight, and its relationship to the parent molecule is in many cases easily traced. Cross and Bevan have obtained this acid as a product of the action of sulphuric acid upon the jute fiber (*Chem. Soc. Jour.*, lv., 210), and from cellulose (cotton) by fusion with alkaline hydrates, the percentage yield in the latter case being under certain conditions considerable (*Chemical News*, lxv., 78). At their suggestion I have undertaken an investigation of this point, not merely as empirically of interest, but as affording information of general theoretical value. I take this opportunity of noting the general scheme of the research, with typical results from among those already obtained.

"Fusion" of cellulosic substances with alkaline hydrates has been exhaustively studied from the point of view of the production of oxalic acid; and an elaborate paper by W. Thorn (*Dingler's Journ.*, ccx., 25) gives all the necessary data concerning the decomposition of the celluloses in this particular direction.

The production of acetic acid by the method of destructive distillation has also been largely studied, and quite recently by Chorley and Ramsay (*Journ. Soc. Chem. Ind.*, 1892, 395). The important point elucidated by these observers is the occurrence of a specific and exothermic resolution of the compounds of the cellulosic group; of this decomposition, which takes place at about 300°, the acetic acid appears to be a product. It should be noted that Thorn (*loc. cit.*, p. 27) observed the phenomena also, but under the conditions of fusion with alkalies, and under this condition at a lower temperature, viz., 180°.

In my investigations the results obtained by the above observers are taken more particularly into account. I confine myself to the decompositions determined by alkaline hydrates at the limits of temperature, 120°—150° and 250°—350°.

As typical members of the cellulose group I have taken cotton cellulose and the hydrocellulose obtained from the former by the action of hydrochloric acid, and of the lignocelluloses jute and pine wood. As a compound of more definite constitution to serve as a standard of comparison I have taken cane sugar.

The following factors of the decomposition in addition to temperature as noted above have been investigated: (1) The nature of the alkali, $NaOH$, KOH, $Ba(OH)_2$; (2) relative masses of carbohydrate and alkali; (3) additions to the mixture of oxidizing agents (*e. g.*, K_3FeCy_6, Fe_2O_3, MnO_2) and reducing agents.

The acetic acid produced has been separated by distillation and determined by titration; checking the results by examining for the presence of other volatile acids and confirming in certain cases by conversion of the acid into silver salt and analysis of the latter.

The numbers obtained for the yields of acetic acid vary from 7 to 40 per cent. of the weight of the carbohydrate; the results with the cellulose compounds are similar to those with the cane sugar. There is a considerable production of acetic acid at the lower temperature (125° to 150°), increasing with the duration of the action and also increased, *ceteris paribus*, with the addition of mild oxidizing agents; the production of acetic, as of oxalic, acid is greater with KOH than with $NaOH$. A considerable production of acetic acid has also been found to occur in certain industrial processes where vegetable fibrous materials are boiled with dilute alkaline solutions (1 to 2 per cent. Na_2O) at temperatures not exceeding 110° C.

Under the conditions of my experiments there is, as is well known, a considerable evolution of gas. This will be examined for CO and CH_4 in addition to H.

These researches as far as they have proceeded lead to the following conclusions: (1) The complex carbohydrates (saccharocolloids) break down ultimately under the action of alkalies at high temperatures similarly to those of lower molecular weight; acetic acid is a main product of the decomposition; (2) the formation of acetic acid at low temperatures indicates the presence of a $CO—CH_2$ grouping as equally characteristic of the former as of the latter, and from the maximum yields obtained it would appear that it is rather a simple product of resolution than of drastic oxidation, *e. g.*, of alcoholic groups, $CHOH$ and CH_2OH; (3) observations upon bodies of known composition indicate that this resolution of the celluloses by the alkalies is preceded by the formation of lactic derivatives. The research is in progress, and detailed communications will be submitted in due course.—*Chem. News.*

SYNTHESIS OF CAOUTCHOUC.

Isoprene is a very volatile liquid hydrocarbon, boiling at about 36° and having the molecular formula C_5H_8. It was first obtained among the products of the destructive distillation of India rubber, and was subsequently found by Tilden among the more volatile compounds obtained by the action of a moderate heat upon oil of turpentine and other terpenes. He noted that when brought into contact with strong acids it was converted into a tough, elastic solid, which appeared to be true India rubber. Specimens of isoprene made from several terpenes were preserved, and he has recently found the contents of the bottles containing that made from turpentine entirely changed in appearance, the limpid, colorless liquid having changed to a dense sirup, in which floated several large masses of a yellowish solid. This, upon examination, proved to be India rubber. He suggests that spontaneous polymerization may have been induced by the production of a small quantity of acetic or formic acid, caused by the oxidizing action of the air. The characters of this artificial caoutchouc appear to agree remarkably with those of Para rubber.—*Chemical News.*

SILICA IN PLANTS.

The proportion of silica in plants at different stages in their development, and the mode in which it occurs, has been the subject of a series of experiments by MM. Berthelot and Andre. The observations were made on wheat, the grains of which contain scarcely a trace of silicic acid. Grains were sown on April 15. On April 30 the greater part of the silica contained in the stem was found to be in the insoluble condition, and must, therefore, have undergone a transformation since its absorption. On June 12, on the other hand, the chief part of the silica was soluble in alkalies. On June 30, at the commencement of the blossoming period, the proportion of silica present was largest in the leaves, smallest in the inflorescence; the former was chiefly in the insoluble, the latter in the soluble condition. Nearly the same results were obtained on July 23. An examination of dried plants on August 18 showed that the amount of silica had increased considerably in the stem and leaves, but only slightly in the ear.—*Comptes Rendus*, cxiv., 257.

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